PROCEEDINGS

OF THE

TENTH ANNUAL CONVENTION

OF THE

American Railway Engineering and Maintenance of Way Association

HELD AT THE

AUDITORIUM HOTEL, CHICAGO, ILLINOIS

March 16, 17 and 18, 1909

VOLUME 10

PART I

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BUSINESS SESSION.

PROCEEDINGS.

This Association is not responsible, as a body, for the opinions or views expressed by individual members.

TUESDAY, MARCH 16, 1909.

MORNING SESSION.

The convention was called to order by the President, Mr. William McNab, Principal Assistant Engineer, Grand Trunk Railway System, at 9 a. m.

The President:—The Chair desires to extend a very cordial welcome to the members to this tenth annual convention. It is particularly gratifying to note the large attendance at the beginning of the first morning session, and such may be taken as indicative of the interest that is taken in our proceedings.

The first item of business is the presentation of the Minutes of the last annual convention. As it is desirable to economize as much time as possible, and as these Minutes have been in your hands, the actual reading will be dispensed with, if there be no objection. There being no objection, the Minutes will stand approved.

The next order of business is the President's convention address.

PRESIDENT'S ADDRESS.

Your Association has completed a decade of active work, and during that period has made an enviable record, and now occupies a prominent position in the front rank of railway organizations and engineering societies.

The advantage gained by this status turns on the beneficial influence it exerts in connection with the objects of the Association—the advancement of knowledge pertaining to the scientific and economical location, construction, operation and maintenance of railways—an influence which has been imparted to the railway world in a degree of usefulness, universal in its scope and almost unparalleled in its

import. This feature should be especially gratifying to the members on this particular anniversary. More especially should this appeal to us as few, if any, kindred bodies have, within the same period or similar length of time, acquired the growth, stability, practical usefulness and, in general, the high standing attained by your Association.

In modern days, the science of Railway Engineering occupies a wide range in the domain of Civil Engineering in the generic sense. This fact was appreciated even in the early days of railway construction, by the compilers of the lexicons of that period, the term "Civil Engineer" being defined by them as "one who plans railways, harbors, docks, etc."—railways apparently being given first place in importance.

From these early days down to the time when the present classification of expenditure was introduced, each railway was practically a law to itself in regard to physical standards, as well as to clerical and accounting methods considered necessary for its proper care.

In the course of time, however, the field covered by what is comprehended under the term "Railway Engineering" became so enlarged and so important that direct supervision in detail from one source was found inadequate, even though the authority enjoyed the broad title of Civil Engineer.

During that period there was, in a more or less degree, a lack of proper appreciation of the value of technical education and training as an adjunct to the practical working of the railway, and the results of experiments made from time to time by certain railways individually to establish a justification for proposed changes were, in regard to real value, not altogether satisfactory to the railway world in general. The experience gained from such investigations, desirable or undesirable as the case might be, was often acquired only after the expenditure of large sums of money, direct or indirect, and the ascertained facts were jealously guarded by the interests concerned.

To the railway world, however, the results of such investigations, even if known to be of benefit, did not meet all the requirements essential to a comprehension of what was expedient from an economic standpoint, and the lesson which should have been taught, viz., that as much, if not more, valuable experience is to be acquired through failures rather than from successes, was not properly brought home.

The textbooks upon particular subjects connected with Railway Engineering in use in earlier days were produced under private or individual auspices. As a general rule they were ably edited, yet the perspective embraced was circumscribed by reason of existing circumstances, and the value of their use was necessarily limited on account of lack of systematic re-issue of such volumes with supplements to meet changing conditions. Special articles upon railroad technical matters which appeared from time to time lacked the value of full discussion, and information thus imparted did not meet requirements; therefore, the interest created could only be looked upon as more or less temporary and superficial.

Railway Engineering, as a great department of knowledge, eventually came to be so subdivided in order to meet the conditions of the times, that each subdivision practically developed into a distinct science, yet each department retained possession of all the elements tending to form a harmonious whole. Evolution in this respect, however, progressed slowly, and the methods and standards in use were in many instances adhered to too long, partly because their chief recommendation lay in the fact that they were time-honored or that there was a lack of knowledge of better substitutes.

Nowadays, fewer textbooks on details of railway construction and maintenance emanate from private sources, for the output of your Association, viz., the conclusions and principles of practice emanating from its various committees, which eventually find their way into the Manual of Recommended Practice, have become the source of appeal in their respective spheres. If reference be made to the discussions preceding the adoption of such conclusions and principles of practice to be found in our Proceedings, it will be noted that every detail has been thoroughly covered.

The bibliography of your Association is, in consequence, liberally made use of to advantage, not only by the members, but by the executive officers of our railways, as being practically authoritative on railway technical details. In this general connection, we are amply justified in stating that there need be no hesitancy in accepting as good modern practice, based upon scientific methods, the general principles which are recommended therein. You are all aware that before any of the various recommendations are adopted and disseminated, they have been thoroughly discussed and voted upon in open convention by the most competent and up-to-date body of railway engineers to be found anywhere, and in no other organization is there a greater degree of care exercised to guard against inconsistencies than is exhibited in our own.

But while there is every reason to be proud of our achievements during these past ten years, we should not rest content, but endeavor to keep our work up-to-date by eliminating from our Recommended Practice what in course of time has become obsolete and perfecting that which is considered worthy of retention, in order that our recommendations may be safely relied upon as representing the best practice that can be devised for the time being.

In no quarter of the world do the diversities of nature, both physical and climatic, exist in a greater degree than on the North American Continent, and for this reason the problems confronting railway engineers afford ample opportunity for the exercise of that particular knowledge which your Association was formed to advance, namely, that pertaining to the scientific location, construction, operation and maintenance of railways.

Great progress has been made in that respect since the formation of your Association ten years ago, as will be noted by reference to the

historical sketch prepared by the Secretary. It is realized more fully that the railway problems coming under our immediate purview are being brought under the influence of common conditions and tendencies.

We meet the propositions which ever present themselves with the knowledge that conditions to-day are not to be governed entirely by the experience acquired in earlier days. It is our endeavor, also, to realize how in carrying out the objects of the Association, true economics requires proper discernment between what is expedient and what is essential, as well as a clear insight into what will tend to the permanent commercial success of the companies by whom we are respectively employed. We are also striving, and not unsuccessfully, for a better understanding of the relationship of capital invested to maintenance and operating expense. In this respect it is borne in mind that as the ratio of progress of all kinds is ever increasing, and that as railways are commercial undertakings, the various factors which produce the greatest permanent profit per cent. of the expenditure, as well as those which have an adverse effect, must be carefully studied. We realize more and more the value of a free exchange of experiences and the practical uses that such exchanges can be put to as well as the results brought about by scientific analyses of theories that have not yet been put to experimental tests.

Since your last convention, the Board of Direction, as well as the Association as a whole, have been called upon to sustain a heavy loss in the removal by death of two of its most valued members, namely, your late President, Walter G. Berg, and D. D. Carothers, member of the Board of Direction. In every department of the Association's interests with which they were respectively connected, their work was accomplished with a thoroughness that left a deep and lasting impress upon the minds of their colleagues and fellow-members, while the genial personality of each endeared them socially to the membership generally. Opportunity will be afforded during this convention for remarks from members eulogistic of the life and character of both the deceased officers.

Your President having been actively connected with the Association since its inception, desires now to bear testimony to the zeal shown by the officers and directors in shaping the destiny of the Association, and guarding its best interests. Acknowledgment is also made of the earnest devotion of the chairmen, vice-chairmen and members of the committees, and of the members of the Association individually in the work, and it may be accepted as entirely within the limits of modesty if it be said that by reason of the elements just mentioned the work has been carried on with a degree of perfection that otherwise would have been impossible.

It may also be said that during the past decade railway construction could not have progressed to the extent and in the manner it has, nor the railways themselves been as efficiently maintained as they have been and are being maintained, if it had not been for the organization

and co-operation shoulder to shoulder, individually and collectively, of the members of the American Railway Engineering and Maintenance of Way Association. (Applause.)

The President:—We will now call for the reports of the Secretary and Treasurer.

Secretary E. H. Fritch presented the following reports:

REPORTS OF SECRETARY AND TREASURER.

March 15, 1909.

To the Members of the Association:

The following report is respectfully submitted:

FINANCIAL STATEMENT.

Balance cash on hand March 15, 1908		$15,852.06
Receipts during the year	$13,078.36	
Expenditures during the year	12,782.85	
Balance to credit	$ 295.51	295.51
Balance cash on hand, March 15, 1909		$16,147.57

EXPENDITURES IN DETAIL.

Stationery and printing	$ 621.66
Proceedings	2,655.33
Bulletins	2,899.19
Postage	477.43
Salaries	3,369.96
Officers' expenses	141.60
Annual meeting expenses	749.07
Telephone and telegrams	135.52
Committee expenses	322.80
Rents	720.00
Expressage	279.89
Exchange	19.25
Supplies	145.81
Light	17.94
Equipment	97.70
Miscellaneous	130.00
Total expenditures	$12,782.85

IMPACT TEST FUND.

Total amount of fund	$ 5,581.74
Amount expended to date account impact tests	5,314.82
Balance of fund on hand	$ 266.92

MEMBERSHIP.

Membership last annual report		680
Members admitted during the year		120
		800
Deceased members	8	
Resignations	8	
	16	16
Membership date of this report		784

The following members died during the year: Walter G. Berg, D. D. Carothers, H. G. Fleming, Theo. Schidlovsky, E. E. Styner, J. W. Leahy, Dennis Sheahan, C. E. Sheriff.

Respectfully submitted,

E. H. Fritch, *Secretary.*

The President:—You have heard these reports; what is your pleasure?

Mr. W. G. Besler (Central Railroad of New Jersey):—I move that the reports be accepted and placed on the Minutes.

(Motion carried.)

The President:—The Chair extends the privileges of the floor to railway officials and to college professors not members of the Association, to take part in the discussions.

The Chair would request that each member rising to speak for the first time will announce his name clearly in order that the reporter may get it accurately and that he may be made known to the membership generally.

The first report for consideration at this session is that of the Committee on Uniform Rules, Mr. R. C. Barnard, chairman.

(See report, pp. 51-55; discussion, pp. 56-69.)

The President:—The Chair would say, in regard to the work which was uppermost in the late Mr. Berg's mind, in safeguarding the interests of the Manual, which he carried out so effectively, that the Board of Direction has delegated Mr. Edwin F. Wendt to carry on that particularly good work that Mr. Berg was so eminently fitted for. It is no doubt an arduous task, but I am sure the members all recognize Mr. Wendt's ability for taking charge of any hard and close work, and he will do so right through the sessions of this meeting. The Chair makes this announcement for the reason that Mr. Wendt may have occasion to take the floor frequently.

The President:—The next report is that of the Committee on Signaling and Interlocking, Mr. A. H. Rudd, of the Pennsylvania Railroad, chairman.

(See report, pp. 71-207; discussion, pp. 208-234.)

The President:—Gentlemen, one of the best and most extensive exhibits of the Road and Track Supply Association in its history is now being held in the Coliseum. It has been decided that this Association adjourn promptly at four o'clock in order that the members may have an opportunity of visiting that exhibit in a body. With that early closing in view the Chair would ask the members discussing re-

ports and matters connected with them to be as precise and as much to the point as possible.

(Vice-President Snow in the chair.)

The Vice-President:—We will now take up the report of the Special Committee on Brine Drippings from Refrigerator Cars, Mr. J. C. Mock, of the Michigan Central Railroad, chairman.

(See report, pp. 235-243; discussion, pp. 244-247.)

The Vice-President:—The next report is that of the Committee on Yards and Terminals, Mr. F. S. Stevens, of the Philadelphia & Reading Railroad, chairman.

(See report, pp. 249-331; discussion, pp. 332, 333.)

(President McNab in the chair.)

The President:—We will now call for the report of the Committee on Rail, Mr. Chas. S. Churchill, of the Norfolk & Western Railway, chairman.

(See report, pp. 334-392; discussion, pp. 393-396.)

The President:—The Chair would take this opportunity of congratulating the Association for being well up to schedule time on these reports so far, and to thank the members for the promptness with which they responded to the invitation to be here at two o'clock to-day. Now, every good deed should have a reward, and with that in view the Chair would ask the members of the Association to take a holiday from now until eight o'clock. There are two very important committee reports to consider to-night, Track and Ties. Let me hope that you will all enjoy and profit by what you see at the exhibit this afternoon.

(Adjournment until 8 o'clock.)

EVENING SESSION.

The President:—The first feature this evening will be memorial remarks in connection with the late Walter G. Berg and the late D. D. Carothers.

You will no doubt recall the events connected with the last day of the convention of twelve months ago, when on that occasion you elected to the presidential office a gentleman widely known and one of the most respected and esteemed members, not only of this Association, but of the engineering profession in general. I refer to the late Walter G. Berg. Under his guiding hand an exceptionally brilliant year was anticipated. This opinion was held not only by the Board of Direction but by the members generally, and I am sure that the late Mr. Berg, despite the modest nature he possessed, was of the

same opinion. But, gentlemen, hardly had one official act been consummated when the hand of Death claimed him, and by one fell swoop, as it were, demolished the anticipations that we held in regard to his prospective administration. It seems to the Chair as being fit and proper that this Association should place itself on record by having a suitable resolution not only inscribed on our Minutes but a copy of such sent to the representatives of the family of Mr. Berg, a resolution which will show the appreciation in which he was held by the Association. Some member will no doubt make a motion embodying the sense of the Association in regard to the worth of the late Mr. Berg.

Mr. A. W. Johnston (New York, Chicago & St. Louis Railroad) :—Mr. President, it seems but yesterday since I had the honor and pleasure, at the close of the ninth annual convention, to make the announcement that Mr. Berg had been elected President. Those who were here then but little thought that in a short twelve months, in this same place and with the same surroundings, we would meet to record our estimate of his virtues as a parting memory. Those who were here that afternoon will well recall the modesty and the self-effacement with which he accepted the honorable office to which he had been elected and the exceedingly nice way in which he introduced his ideas of those measures which, in his judgment, would tend to increase the usefulness and power of this Association. The Board of Direction, after his death, through a proper committee, have had recorded an estimate of his life and achievements, but it seems to me proper at this time, for the organization as a whole, here assembled, to take further note of the sad occurrence, and in a sense to make a brief summary of the salient points of his career, which will be recorded upon the Minutes of this meeting and a copy sent to his family as our last expression in relation to his sad taking off, and I, therefore, in behalf of your Board of Direction, offer the following Minute to be spread upon the record of this meeting and a copy to be sent to his family:

"Walter G. Berg, the sixth President of the American Railway Engineering and Maintenance of Way Association, died May 12, 1908, in his fiftieth year. It is befitting that at the close of the term for which he was chosen, the work of which began so auspiciously under his guiding hand, that this Association make record of its lasting obligation for his services in its cause, and set forth an estimate of his character and his accomplishments.

"His connection with this Association was made early in its organization. The story of its progress cannot be made without recording his individual part therein. The impress of his character, of

his method, of his thoroughness, and of his conscientiousness is deep and lasting.

"The science of Railway Engineering, as expressed in the records of this Association, reflects his painstaking genius, his wise forethought and his sound business sense.

"As a fellow-laborer in the field of science he was tolerant and helpful.

"As a leader in the organization he had the courage of his experience, and the quiet force which induced conviction.

"In the brief period of his service as President he manifested a wide grasp of affairs and a thoroughness in details portending a brilliant administration.

"In his varied relations to the work of the Association, his simple character, his modesty, his self-effacement, won the enduring regard of his co-laborers in our cause.

"The ties of affection and all that made life sweet were severed almost in the twinkling of an eye.

"To those who were near and dear to him, this Association tenders its profound sympathy.

"The keenness of their grief is tempered by the consoling reflection that the memory they cherish is not alone sweet to the senses of their affection, but in that wider circle where his life's work was accomplished, the fragrance of his memory will forever linger."

Mr. L. C. Fritch (Illinois Central Railroad):—I second Mr. Johnston's motion and suggest there be a rising vote.

The President:—Before putting the motion we would be glad to hear from some of the other members.

Mr. E. F. Ackerman (Lehigh Valley Railroad):—Mr. President and Members of the Association, I consider it an honor to be privileged to make a few remarks concerning our friend and Past-President of this Association, the late Mr. Berg. It was my good fortune to have been intimately associated with him for the past ten or twelve years, and, therefore, perhaps, appreciate, to a greater extent than most of us, the great loss that not only this Association, but the engineering profession at large, has suffered by his untimely death.

It is not necessary for me to dwell at length upon his interest in this Association. His untiring labor, his ever-increasing enthusiasm and his personal influence are familiar to us all.

It is, perhaps, concerning his personality as a railroad official, that I am best qualified to speak. As a subordinate he was ever courteous, painstaking and loyal, and at all times exhibiting that untiring zeal so characteristic of him.

As a superior, his kindly consideration and personal interest in

his subordinates was universally known and extended from the highest to the lowest positions under him. He likewise took the same interest in men of other associated departments. He was always open to conviction and encouraged the advancement and discussion of opinions. His advice in personal and professional matters was always given, often at considerable personal inconvenience.

Thoroughness was the keynote of his success, and many of the results attained by him were attended with exhaustive investigations involving an application that would discourage the average person. With him, however, hard work was a pleasant recreation.

With regard to his family life, I always considered it ideal. He was a kind and loving husband and father and a dutiful son. The latter years of his life were saddened by the loss of his wife, to whom he was exceedingly devoted. I sometimes think that he endeavored to lighten his sorrow by keeping himself constantly occupied by hard work; but withal, he never lost sight of his home ties and household, which received the same thorough attention so characteristic in his business affairs.

Personally, I have lost a friend who was, in effect, a father to me, and I am quite sure that this feeling is shared by others who have had the good fortune of his association.

The Association, too, has lost an incessant worker and champion, and the profession and educational circles have suffered similarly.

I fear that my remarks only feebly extol the character of our departed member, and, with a view of doing full justice to his memory, if possible, I will suggest that, as there are no doubt a number of men with us to-night who have been intimately associated with Mr. Berg in various railroad associations, they be called upon to present that phase of his activity and tell us of his personality as reflected to them.

Mr. J. B. Berry (Chicago, Rock Island & Pacific Railway):—Mr. President, Mr. McNab asked me at the close of the meeting this afternoon to say something about Mr. Berg. I have not had much time to prepare anything, but I am glad to add my tribute.

My acquaintance with Mr. Berg began about ten years ago. I saw but little of him until the St. Louis Exposition, when we served on the same sub-committee on work assigned us by the Committee of the Whole on Transportation. Most of the time he and I were the only members of our sub-committee who worked. I then learned to appreciate, in a measure, his great industry, methodical habits, and desire to do everything in the most thorough manner, and,

more than this, it brought out the many lovable qualities of the man, such as you could only see from daily association.

He never seemed impatient, no matter how much time an exhibitor wanted, and he wanted to be eminently fair and just to all. This was brought out very clearly when at night we classified the various exhibits. From that time on I saw a good deal of him.

He seldom referred to his own work as an Engineer, but occasionally his conversation revealed his preparation and the kind of work he had been doing all his life. He told me of the work he did at home nights, and the great pleasure it gave him to prepare papers of his own and edit those of others.

I have often thought that in the great hereafter Engineers would probably be recognized, and I am sure that Walter G. Berg is entitled to a front seat.

Mr. H. S. Balliet (Grand Central Terminal and New York Central & Hudson River Railroad):—Mr. Chairman and Gentlemen, Mr. Berg and I were very closely related in our routine, the few years that I was employed on the Lehigh Valley, but I would like to repeat, almost verbatim, the words of the last speaker. He never knew what it was to stop work. He was always ready to assign to those under him new duties. I know of occasions when he would leave us at the office on an evening and say, "Well, you can typewrite that report now, and to-morrow we will turn it in." On the following morning, bright and early, he was at the office with two or three other schemes for doing the same thing, he having worked about all night to determine upon what he considered the proper method. He had them all worked out in detail, and said, "Now, do it that way." He was a great leader and pointed the way, not only because he had the education, but because of his large capacity for detail. He grasped things promptly and applied them in the very best way.

The President:—We would like to hear from Mr. Schall, of the Lehigh Valley Railroad.

Mr. F. E. Schall (Lehigh Valley Railroad):—Mr. President, Members and Friends of this Association, I did not expect to speak on the subject of my departed Chief and President of this Association, but since you have called upon me I will say a few words.

It was my privilege to be associated with Mr. Berg for nearly twenty-five years, and in this time I have had full opportunity to observe and experience the strong character of the man. As a man Mr. Berg was kind and just, always ready to meet you on a fair plane; he was a kind and loving husband and father, and a most dutiful son

to his parents. I think that especially during the latter years Mr Berg sacrificed his ambition and chances of position to the love for his old parents, desiring to be near them.

As an Engineer and professional man, you know him; it is not for me to say much on that point, his works speak for him; I will only refer to one of his characteristics: Mr. Berg was a most generous superior, he was the most liberal to give advice, not only to his subordinates and co-workers, but also to his friends and acquaintances, on any subject, and if he had it not at his fingers' ends, he looked for it, and most cheerfully spent his time to assist others. Mr. Berg was especially kind to young engineers; this is best expressed in the latter part of a memoir, published in a Lehigh Valley Railroad publication, "The Black Diamond Express," when it said:

"Though his cup of honors was filled to o'erflowing, though he stood on an eminence reached by but a select few, it is not by the learned and scientific that he will be so sadly missed as by those who were his immediate associates, many of whom to-day are on the high road to place and preference owing to his friendly advice and assistance, his judicious, sagacious counsel and help. From his high eminence he ever reached down a helping hand, and with the gentle monition of 'friend, come up higher,' strove to help them to a more elevated plane in their chosen profession. By these he will be truly missed, by these will he be deeply mourned."

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis Railway):—I have known Mr. Berg only during his connection with this Association. He was known to me, however, by reputation long before that through the books he had given to the public and through his connection with kindred associations. I always very much admired his efforts in a literary way, and I found them very helpful to me in my work, and I was particularly struck with the influence that his work had on the associations with which he was connected.

I believe that Mr. Berg has brought to this Association the same happy influence that he conferred on those to which he belonged before he came to us, and as a member of the Board of Direction I want to say that Mr. Berg's untiring zeal and constant interest in this Association has done as much as that of any other man, if not more, to bring it to its present condition.

Mr. J. P. Snow (Boston & Maine Railroad):—I would bear testimoney to the great worth of Mr. Berg to his fellow-engineers. He was a great worker for associations like this. I first met him perhaps fifteen years ago, when he was president of another association work-

ing on somewhat similar lines to this one, and he was the light of that association in its early days. Long before that I had known him by correspondence as a very earnest enthusiast in anything pertaining to engineering construction. I simply wish to add my testimony to what has been said by others.

Prof. C. Frank Allen (Massachusetts Institute of Technology):—It did not fall to my lot to know Mr. Berg intimately. I had not the pleasure of close acquaintanceship with him, but I would like to add my tribute of respect, and desire to call to mind particularly one phase of Mr. Berg's life. Although a busy railroad man, he found opportunity, before this Association was organized, to contribute in a valuable way to engineering literature; to railroad literature. There is very little railroad literature produced at the hands of men in active practice, and to me it is very gratifying that a man as busy as he was, found time to contribute as much as he did to railroad engineering literature. The necessity for it, since the formation of this Association, is less, perhaps, than at the time his books were written. Nevertheless, I cannot help feeling that the example he set in that way is one that can be taken to heart by many others. I hope that the influence of this example will bring fruit in the work of other busy men who have something they may be able to contribute.

Mr. W. M. Camp (Railway and Engineering Review):—It is not a task for me to recall pleasant things to the memory of Mr. Berg. I was intimately acquainted with him for many years, and I know a great deal about his methods of work and what he did for the cause of engineering education when associations were not as numerous as they are to-day. I only regret that I did not come with some preparation for these eulogies, inasmuch as the remarks that are being made are intended to be formal and are being placed on record.

There is one thing that I want to say about Mr. Berg, and that is that he started out in engineering practice with a thorough theoretical education. He graduated from an engineering institution in Germany, and took a great deal of what would ordinarily be called post-graduate work. He then returned to this country and engaged in engineering work, and he seemed to get hold of practical ideas from the start. I do not know of a better example of a man highly educated theoretically who could at the same time be thoroughly practical. It seemed that he was continually planning how to make use of his knowledge in practical ways.

He once told me how he got up that well-known book of his on "Buildings of American Railways;" the large number of blueprints

which he carefully studied over and many of which were reproduced in the book. He was a great worker, trying to turn to useful purpose many matters which the ordinary engineer would regard with only passing interest. He had a system of his own for filing such information as attracted his attention. Being an omnivorous reader of engineering literature, not only in English, but in foreign languages, whenever he ran across something that he thought might be useful in time he clipped it out, and he had a series of boxes set aside for certain classes of articles, and would place the clippings in these boxes. He considered the card index system too bothersome.

I think one important source from which Mr. Berg derived benefit and which would explain much of the development of his usefulness as an engineer, was the part he took in technical associations. He was a member of the Roadmasters' Association for many years and wrote papers for it; he was a prominent member of the Association of Railway Superintendents of Bridges and Buildings, and for many years edited the proceedings of that association.

There was another characteristic of Mr. Berg which is admirable of him—he never neglected small things; he gave attention to them as well as to the larger questions. Those of us who have observed his methods in the work of this Association can testify to his watchful care over the discussions. He was never contented to see a matter pass the convention unless it was in some definite shape and as complete as it was possible to have it.

Mr. Berg was a decided gentleman, and a man with a warm heart, always ready to assist any person who had an inquiry to make of him. His obliging and genial disposition was evident at all times, and his conversation was agreeable to all who had the good fortune to meet him. Broad-minded and exceedingly well-informed, he was not much concerned about reserve, and what he had to say about a subject was usually frank and forceful. His habit of going to the bottom of questions, and his readiness to impart the results of his constant striving for knowledge, without ostentation or formality of address, were unusual. The simplicity of the man, his quiet manners and the honesty of his convictions were a reinforcement to his mental strength. The openness of his mind and his deliberate methods marked him for one to be sought in counsel, as those who have the direction of the affairs of this Association well know. Mr. Berg was, indeed, a man of rare mental attainments, and the excellence of his character was just as conspicuous as was his ability.

The President:—If you are in favor of the terms of the resolu-

tion as Mr. Johnston has proposed, and Mr. Fritch has seconded, being inscribed on the Minutes of the meeting and a copy transmitted to Mr. Berg's family, I will ask you to rise.

(The resolution was unanimously adopted by a rising vote.)

The President:—The Board of Direction of the Association was doubly bereaved since the last annual convention. On the second day fo January of this year we had to face the loss by death of D. D. Carothers. In all the departments of the Association's work with which Mr. Carothers had been connected, he showed great devotion to that work—as an individual member, as chairman of a committee, and as a member of the Board. We are sure his death was most keenly felt by every member of this Association. It may be trusted that a similar resolution as has just been passed in connection with the death of Mr. Berg will be adopted also in regard to the late Mr. Carothers.

There was a Committee of the Association appointed to prepare a memorial, and such memorial is in your hands. The Committee consisted of I. G. Rawn, chairman; L. C. Fritch, A. W. Thompson, J. E. Greiner, Francis Lee Stuart and R. N. Begien.

Mr. L. C. Fritch:—I have been requested by the chairman of the Committee, Mr. Rawn, to present the report of the Committee. Mr. Rawn regrets he is unable to be present personally, but he was unavoidably detained and asked me to present the report for him. In that connection he also wanted me to pay tribute to Mr. Carothers' memory in his behalf. There is probably not another man in the railroad world who was more closely associated with Mr. Carothers than Mr. Rawn. Mr. Rawn was General Superintendent of the Baltimore & Southwestern at Cincinnati when Mr. Carothers was Engineer of Maintenance of Way. They were almost inseparably associated for twelve years. They were constantly together and were like two brothers, and Mr. Rawn wanted me to say for him that when Mr. Carothers was called away he felt as if he had lost a member of his own family, and desired to express to the Association his deep sense of loss.

The President:—Mr. Thompson, will you say a few words?

Mr. A. W. Thompson (Baltimore & Ohio Railroad):—While I most sincerely welcome every opportunity to speak of the love and honor in which, one and all, we hold the memory of our former Director and friend, the late Daniel Dawson Carothers, it is with some reluctance that I attempt the task here to-night. Although I knew Mr. Carothers for almost ten years, and was intimately associated with

him for two years previous to his death, I have no question that there are other members of this Association present who, having been his close personal friends for a much longer period than I, are better qualified to tell of his many strong and lovable characteristics; so dominant that even a new acquaintance was immediately attracted to him, and in a very short time felt that he had been a lifelong friend, while those of even slight acquaintance carried away from his presence a lasting remembrance of the strong impression made upon them.

A man of striking physique and noble spirit, always having an expression of happiness, cheerfulness and welcome, no matter under what strain of duties or difficulties he was laboring, and never so busy that he turned away any man with a curt answer. Eminently well-balanced, conservative and remarkably even-tempered, he weighed all matters carefully, listening with attention to whatever anyone had to say, and after digesting the whole question, would make his decision and abide thereby, subsequently bending his energy toward accomplishing the results desired, and his successful career is proof of his rare good judgment and unfailing ability to well forecast the outcome.

On the Baltimore & Ohio Railroad Mr. Carothers was personally known to employés from the President, Directors and officers, down through the rank and file, and also by many of the leaders in the commercial world, with whom he was thrown in contact while conducting the business of his office. From all he received the respect and admiration so deservedly due him for his ability and common-sense, but those who knew him best and longest were the ones who really learned his truly sterling qualities and appreciated them the most.

Leaders to take the responsibility of a final decision there must be, but outside of business affairs Mr. Carothers met all worthy men as social equals, never carrying with him a false dignity of position. He brought to bear noticeably strong traits in his daily work, his manly bearing and straightforward actions commanding an intuitive regard from all coming in contact with him. His was one of the rare natures which could indulge in an intimacy with his subordinates and yet inspire their unbounded respect, and it was his aim to gather around him, as co-workers, an energetic, clean staff of men. He gave particular attention to the personnel and development of those reporting to his office, and it afforded him the keenest delight to see a young man expand under his guidance and encouragement. A favorite comment of his, often made concerning railroad work, was that "the

great leaders in the railway world were to be judged by the men on their staffs assisting them." Many young men, some of whom are well known, and to-day occupy positions of responsibility, owe their success in a large measure to his kindly thoughtfulness and advice.

In all his intercourse with his assistants, he never made them feel that they were reporting to him personally, but to his office, where all were working together to further the best interests of the company. A big man in every sense of the term, he freely gave aid and assistance to the young men from the great storehouse of his varied experience and information—of which he seemed to have an inexhaustible store—and in him was realized the truth of the adage, that "men grow strong upon that which they give away."

Mr. Carothers was a member of many social clubs, as well as a large number of railroad and engineering societies, but the American Railway Engineering and Maintenance of Way Association always received most of his attention and thought, he being at all times actively alert to further its progress and make it a powerful factor in securing the solution of railroad problems.

The social clubs he visited but little, giving his devotion to his home and to her who bore his name, this lovable trait impelling frequent and admiring appreciation on the part of those conversant with the beautiful domestic side of his life.

While Daniel Dawson Carothers wrought out so enviable a position for himself in the railway world as Chief Engineer of the Baltimore & Ohio Railroad, had made that office a greater and broader one than ever before, it was felt by all that his career was relatively but just begun. His death, as we all can most sadly testify, was a great loss to the engineering world, to the railroad in the upbuilding of which he had spent his best days, and is a deep personal one to all of us who knew him.

In making these remarks it is in no wise the intention to exaggerate or flatter, but rather to pay just tribute to a truly unusual man. To the average man is not bestowed the ability to adequately express his emotions on such occasions as this, and these few words in loving remembrance of Mr. Carothers seem meager and to fall short of what we would wish. Nothing, I feel, could be more apt in closing than to quote the conclusion of the Memoir published by this Association:

"The world is better because he lived.
A noble spirit has gone to rest."

Mr. President, I would like to offer the following resolution:

"WHEREAS, In the death of Daniel Dawson Carothers, former Director, Chairman of the Committee on Rail and past-Chairman of the Committee on Uniform Rules, this Association has lost a valued member, a wise counselor and an untiring worker; his connection with the Association beginning with its formation, later assisting in perfecting the organization, becoming a Charter Member and devoting much of his time and energies to the work of the Association, throughout his entire connection with it, and extending over a period of nearly ten years; therefore be it

"*Resolved*, That this Association, in convention assembled, hereby expresses its appreciation of the worth of Daniel Dawson Carothers as a member and officer of this Association, and its sincere regret for the loss occasioned through his untimely death; be it further

"*Resolved*, That the Association extend to the wife and family of our deceased member its deepest sympathies, and that the sorrowing wife be notified of the action of this Association."

Mr. Earl Stimson (Baltimore & Ohio Southwestern Railroad):— I would like to second that resolution, and in doing so wish to add a few words of tribute to Mr. Carothers. I began my railroad experience about fourteen years ago with Mr. Carothers. I had just come out of college and, of course, was new to the work. He took a kindly interest in all young men who came into his office, as well as all other subordinates. He seemed to take personal pride in developing them and starting them on the right path. I know that I am indebted to him for what I have made of myself, and I know that there are a great many other men who owe him the same debt. He seemed to draw out the best that was in a man. He reposed confidence in them and in turn the men gave him a co-operation and loyalty that I think helped him largely in his successful work.

Mr. L. C. Fritch:—I would like to offer my personal tribute to Mr. Carothers. It was my good fortune to be associated with him for about fifteen years, most of that time coming into almost daily contact with him; to have known Mr. Carothers as I knew him was to love and admire him. Mr. Carothers had a character that was beyond reproach; he had a disposition such that I think it can be truly said of him that he had no enemies. I never heard anyone speak of him, excepting in the highest terms. He was a man who, as the tributes given before bear testimony, had the confidence of the men under him and those above him. He was kind and considerate to the men who reported to him and he was a man of courage and had the strength to give voice to his convictions to his superiors. Mr.

Carothers took an especial interest in this Association. I remember distinctly the day the call was given for the first meeting of the preliminary organization. Mr. Carothers and I were out on a trip of inspection and it was his purpose to personally attend that meeting, but finding that he could not go he asked me to represent the road, which I did, and from its origin Mr. Carothers showed a deep interest in the Association and its affairs. He was a tireless worker in committee work, and when he entered the directory, I personally know that he was especially delighted. He seemed to be impressed with the dignity and the honor of the position and gave it more than the usual attention. I think we have sustained in our Association, as well as in our friendship, a loss which cannot be replaced.

The President:—Mr. Greiner, we will be glad to hear from you.

Mr. J. E. Greiner (Baltimore & Ohio Railroad):—Mr. President, I was closely associated with Mr. Carothers during the past five years of his life, not only as one of his staff, but as a friend. During that time I never knew him to say an unkind word, to show the least ill-feeling or in any way reprimand a subordinate unjustly. His office was always open to not only his assistants, those who had railroad matters to discuss with him, but to the most humble person on the road who wished to obtain his advice on some personal matters, or to a supply salesman who would take up his time without any special benefit to Mr. Carothers and for the sole benefit of the salesman. He would greet them all with the same kindly smile and make them all feel welcome. His personality was very strong, and, in fact, it is still felt in his office. When any of his old staff go into his office at the present time there is a feeling that, while he is not apparently there, that he will be there soon. This is simply an attempt on my part to describe a character which is really so strong that words can hardly do justice to him. He was a man who took the greatest interest in young engineers. He was a friend of every young man who intended to make something of his life. He went out of his way to help them, not only with advice and encouragement, but in every way that a friend could help a friend. He was regarded by all those who were associated with him as not merely a co-worker or a superior officer, but as a close and warm friend. Those on the Baltimore & Ohio who were associated with him felt that the road lost a truly great Chief Engineer, one worthy in every respect of his position.

Mr. A. M. Kinsman (Baltimore & Ohio Railroad):—I had known Mr. Carothers for ten years. For the past five years I was intimately connected with him, and during that time it was a pleasure to report

to him. I loved the man and respected him the strongest possible way. I considered him a broad-minded man, of a lovable nature, and a thorough gentleman of the highest type, and if there were any words in the English language that would permit me to express my feelings more forcibly than these gentlemen have expressed theirs to-night, I would use them.

Mr. G. W. Andrews (Baltimore & Ohio Railroad):—It was my good fortune to have possessed the friendship of D. D. Carothers, an incident in my life that shall remain vivid to the last moment of consciousness in this world. To have known Mr. Carothers, as a man, could but have the tendency to make one a greater lover of his fellowmen. To know him was to feel that there was a friend to approach in the hour of trouble.

It is, of course, a fact that all of us feel at times that to have someone in whom we can confide will relieve distress of mind and conscience. Such a man was he, and many of his subordinates fell into errors and approached him, not with diffidence or fear, but with the confidence that if there was the least justification for leniency, they were sure to receive it; not only leniency, but help in remedying the trouble; firm when necessity required it, yet always gentle in enforcing his will.

In my intercourse with him I was always deeply impressed with his love for his fellowmen, especially those subordinate to him in the service, which was so much a part of his life. In later years this seemed to increase, and I always thought that Nesbit must have had him in mind when he wrote the second stanza of his poem, "The Value of a Smile:"

> "The smile that bubbles from a heart that loves his fellowmen,
> Will drive away the clouds of gloom and coax the sun again."

On entering his presence, even in the moments of his greatest suffering, we were always greeted with a kind and genial smile, a smile that truly came from a heart free from guile and always filled with love for his fellowmen; a heart strengthened by a soul always strong to do good, ever watchful of the interest of his employers, yet with an eye for the general welfare of the faithful subordinates. An all-wise Providence sees fit at times to place in the various walks of life some one spirit to assist his fellowmen in bearing the harsh shocks of the world, and at the moment we need him the most, removes him from our midst, but, though he is taken, the strength of his character leaves an impression for good that is never eliminated, and we feel rich for having been permitted to come in contact with

such a spirit, and such a one do we feel was the noble spirit that has so suddenly been taken from our midst, and feeling this, it is with love and reverence that I say "Farewell, great and noble spirit."

The President:—Before asking the Association for an expression on this resolution, it would be fitting and proper to hear from some member of the Rail Committee, the Committee with which Mr. Carothers was so intimately connected as chairman. I will ask Mr. Cushing to say a word or two.

Mr. W. C. Cushing (Pennsylvania Lines):—All that I could say would be mere repetition of what has already been said. I would simply say that I had learned in my short acquaintance with Mr. Carothers to have a strong degree of affection, admiration and respect for him.

The President:—Gentlemen, you have heard this resolution proposed by Mr. Thompson, and seconded by Mr. Stimson, and in like manner therefore to the previous resolution, will you show your approval of it by a rising vote.

(The resolution was adopted unanimously by a rising vote.)

Mr. Edwin F. Wendt (Pittsburg & Lake Erie Railroad):—I move that the memorial of Mr. Berg that was printed and distributed last summer be printed as a part of the proceedings of this meeting along with the tributes that were given this evening.

(Motion carried.)

Mr. L. C. Fritch:—I would ask a similar resolution with respect to Mr. Carothers' memorial.

(Motion carried.)

The President:—The report of the Committee on Track, of which Mr. L. S. Rose, of the Cleveland, Cincinnati, Chicago & St. Louis Railway, is chairman, will now be taken up.

(See report, pp. 397-450; discussion, pp. 451-488.)

I will ask the approval of the meeting that the Vice-President take the chair for the remainder of the evening.

(Vice-President Snow in the chair.)

WEDNESDAY, MARCH 17, 1909.

MORNING SESSION.

The President:—The chair would ask the unanimous consent to vary from the program and have the result of the balloting for officers for the year 1909 announced at the close of the morning session. The chair would therefore appoint as tellers K. J. C. Zinck, C. W. Johns and Earl Stimson. The Secretary will turn the ballots

over to them and they can retire to the anteroom and present the result before the morning session closes. The first committee to report this morning is the Committee on Ties.

(See report, pp. 489-520; discussion, pp. 521-532.)

The President:—The next report to be considered is that of the Committee on Wooden Bridges and Trestles, Prof. Henry S. Jacoby, of Cornell University, chairman.

(See report, pp. 533-597; discussion, pp. 598-614.)

The President:—We will now take up the report of the Committee on Wood Preservation, Mr. A. L. Kuehn, of the Cleveland, Cincinnati, Chicago & St. Louis Railway, chairman.

(See report, pp. 615-668; discussion, pp. 669-676.)

The President:—At the opening of the session this morning, the chair asked unanimous consent to vary from the usual program and announce the result of the ballot for officers before the noon recess to-day. The tellers are ready to make their report, and the Secretary will announce the result of the election for officers for the year 1909.

The Secretary:—The tellers appointed to canvass the votes for officers report as follows:

	Votes.
Total number of votes cast	395
For President, William McNab	395
For Second Vice-President, W. C. Cushing	394
For Secretary, E. H. Fritch	395
For Treasurer, W. S. Dawley	395
For two Directors (three years each):	
A. H. Rudd	391
A. W. Thompson	382
A. J. Himes	2
E. B. Cushing	1
W. B. Storey, Jr	1
A. S. Baldwin	1
D. W. Lum	1
S. B. Fisher	1
A. M. Kinsman	1
C. A. Wilson	1
J. R. Worcester	1
M. L. Byers	1
J. W. Kendrick	1
J. B. Berry	1
L. R. Clausen	1

The officers elected are as follows:
President, William McNab.
Second Vice-President, W. C. Cushing.
Secretary, E. H. Fritch.
Treasurer, W. S. Dawley.
Two Directors, A. H. Rudd, A. W. Thompson.

AFTERNOON SESSION.

The President:—We will now take up the report of the Committee on Ballasting, Mr. John V. Hanna, of the Kansas City Terminal Railway, chairman.

(See report, pp. 677-720; discussion, pp. 721-730.)

The President:—The report of the Committee of Water Service will now be considered. Mr. C. L. Ransom, of the Chicago & Northwestern Railway, is the chairman.

(See report, pp. 731-809; discussion, 810-824.)

The President:—Mr. H. R. Safford, of the Illinois Central Railroad, chairman of the Committee on Records, Reports and Accounts, will present the report of the Committee.

(See report, pp. 825-869; discussion, pp. 870-874.)

THURSDAY, MARCH 18, 1909.

MORNING SESSION.

The President:—The chair will ask unanimous consent of the convention to allow Professor Jacoby, chairman of the Committee on Wooden Bridges and Trestles, to occupy a few minutes of your time.

(See statement, p. 614.)

The President:—The first report to be considered this morning is that of the Committee on Signs, Fences, Crossings and Cattle-Guards, Mr. W. D. Williams, of the Cincinnati Northern Railroad, chairman.

(See report, pp. 875-909; discussion, pp. 910-917.)

The President:—We will now take up the report of the Committee on Roadway, Mr. Geo. H. Bremner, of the Chicago, Burlington & Quincy Railroad, chairman.

(See report, pp. 919-1096; discussion, pp. 1097-1106.)

The President:—The Chair will call for the report of the Committee on Buildings, Mr. O. P. Chamberlain, of the Chicago & Illinois Western Railroad, chairman.

(See report, pp. 1107-1128; discussion, pp. 1129-1140.)

The President:—It has been suggested that the convention adjourn at the present time to meet again at 2 o'clock. There has been a

record attendance thus far at this convention. Up to this morning 360 members have registered.

AFTERNOON SESSION.

(Vice-President Snow in the chair.)

The Vice-President:—The Committee on Iron and Steel Structures will please present their report. Mr. J. E. Greiner, of the Baltimore & Ohio Railroad, is chairman.

(See report, pp. 1141-1160; discussion, pp. 1161-1166.)

The Vice-President:—The Committee on Uniform General Contract Forms will now present their report. In the absence of the chairman, the vice-chairman, Mr. E. F. Ackerman, of the Lehigh Valley Railroad, will present the report.

(See report, pp. 1167-1303; discussion, pp. 1304-1309.)

(President McNab in the chair.)

The President:—The Committee on Masonry will present their report. In the absence of the chairman, the vice-chairman, Mr. W. H. Petersen, of the Chicago, Rock Island & Pacific Railroad, will present the report.

(See report, pp. 1311-1414; discussion, pp. 1415-1430.)

The President:—The report of the Committee on Economics of Railway Location will now be taken up. This will be simply in the nature of a progress report. Mr. W. B. Storey, Jr., of the Santa Fe Railway System, is the chairman.

Mr. W. B. Storey (Atchison, Topeka & Santa Fe Railway System):—As I understand it, the rules of the Association require a report to be printed, and no report having been printed there is practically nothing to be said before the Association at this meeting. There has been no meeting of the Committee during the year. The membership is scattered throughout the United States, and it has not been possible to get them to meet and nothing has been accomplished which can be reported to this Association.

The President:—The chair will ask Mr. R. D. Coombs, as a representative of the Committee on Electricity, to make a progress report.

Mr. R. D. Coombs (Pennsylvania Tunnel & Terminal Company):—The Committee on Electricity, which, with two exceptions, is the Special Advisory Committee appointed by the Board of Direction to report upon the propriety of establishing a standing committee, held two meetings as an Advisory Committee and outlined a certain portion of the work. The Committee has recently been appointed as a

Standing Committee, but has not been able to meet since its appointment. The Committee is now organizing to take up the work outlined.

Mr. L. C. Fritch (Illinois Central Railroad):—I offer the following resolution:

"*Resolved*, By the members of the American Railway Engineering and Maintenance of Way Association, in convention assembled, that we desire to express our appreciation of the courteous invitation extended by the Illinois Steel Company and the Universal Portland Cement Company to visit the Gary and Buffington plants on Friday, March 19, 1909."

(The resolution was unanimously adopted.)

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis Railway):—I offer the following resolution:

"WHEREAS, Our efficient Secretary, Mr. E. H. Fritch, has handled the duties incident to his position in a very satisfactory manner and particularly has labored long and faithfully to get the difficult work of publishing the reports of the various committees into proper shape and have them distributed in due season to the members of the Association; now, therefore be it

"*Resolved*, That the Association appreciates the splendid service which Mr. Fritch has rendered in filling the arduous duties of his position and that a vote of thanks be tendered him by the Association at this time."

(The resolution was unanimously adopted.)

Mr. Edwin F. Wendt (Pittsburg & Lake Erie Railroad):—I move the adoption of a resolution to this effect:

"*Resolved*, That this Association appreciates the educational value of the exhibit of railway appliances at the Coliseum, and the high standard upon which the exhibition was organized and conducted."

Mr. L. C. Fritch:—I offer the following resolution:

"*Resolved*, That this Association, through its President, extends to the Hon. George W. Ross its appreciation of the admirable address given at the banquet on Wednesday evening."

The President:—If there is no further business, the Tenth Annual Convention will be declared closed.

Walter G. Berg

Walter Gilman Berg

A Memoir.

WALTER GILMAN BERG, the sixth President of the American Railway Engineering and Maintenance of Way Association, died suddenly at New York, May 12, 1908.

He was born on January 12, 1858. On his paternal side he was descended from Franc D'Angelo, of a distinguished Italian family, which settled in Germany in the eighteenth century. D'Angelo, who, though in mercantile life, devoted much of his time to the gratification of artistic tastes, and, as a contemporary of Goethe, made his home at Frankfort-on-the-Main, the center of an artistic and musical coterie. Mr. Berg's father, Professor Albert W. Berg, was born at Frankfort-on-the-Main, but received his education in France, and though German by name, was essentially French in character. When quite young, after his parents had removed to America, he evinced a decided musical talent, and was sent to Paris to complete his education. On his return he commenced a career as a teacher of music and a composer, which brought to him an artistic reputation of the highest order, ending only at his death in 1906. Professor Berg was married on July 7, 1853, to Miss Helen McGregor Morse, who was descended from English Puritan ancestry; it is worthy of note that Yale College was founded in the house of her great-great-grandfather, Rev. Samuel Russell, a prominent man of his time. She was born in Hanover, N. H., the seat of Dartmouth College. She inherited an inclination to intellectual work, and her environment assisted in developing it.

Walter G. Berg thus came naturally by inheritance to intellectual qualities which permeated his whole life. As a child, at birth, he was very frail, and only by constant care developed a physique which, though slender, permitted great activity even in his nursery days. Even at that early period there were marked indications of that pertinacity of purpose which actuated his whole life. At a very early age he gave evidence of rare musical ability, and all through manhood, while professional duties kept music in abeyance, his facility of reading at sight and natural aptitude was such that he could perform creditably upon the organ or piano, even though he had not touched the instrument for many months.

During his early studies his exceeding vivaciousness often led him into trouble, but he always came out ahead, and perseveringly reached the goal.

Prepared by A. W. Johnston, Howard G. Kelley, Hunter McDonald, W. G. Besler, W. D. Pence.

At nine years of age he was taken to Europe and began a course of education which lasted thirteen years. The system of recreation in vogue at the schools which he attended appealed to him, and he entered heartily into the various sports. He was wont to take, at first with his tutors, and later alone, long foot tours covering Germany, Austria, Switzerland, Italy and France. His bodily strength was thus developed, and his keen powers of observation added greatly to a high degree of culture. His whole university career was marked by eminence in scholarship, which was crowned by the award of the gold medal, offered by the King of Wurtemberg for a treatise on spherical conic sections. The award of this prize was accompanied by the testimony of the committee that not only the accuracy of folio drawing showed superior skill, but the accompanying thesis evinced unusual acquaintance with mathematical literature. Congratulations were showered upon him, and the Polytechnic Institute at Stuttgart awarded him a scholarship, and tendered him employment on government surveys and other marks of distinction.

Returning to this country, he entered railway service in 1879 as Office Assistant and Shop Inspector of Railroad Bridges of the Deleware Bridge Company, and in 1880 entered the employ of the Engineering Department of the Richmond & Allegheny Railroad, serving as Bridge Inspector, Engineer of Bridges and Buildings and Engineer in Charge. In 1882 he entered the service of the East Tennessee, Virginia & Georgia Railroad as Principal Assistant Engineer.

In January, 1883, he entered the service of the Lehigh Valley Railroad Company as Assistant Engineer, in charge of the design and construction of shop buildings and roundhouses, preliminary surveys, location and construction of branch lines, and in charge of Chief Engineer's office.

In 1886 Mr. Berg designed and constructed the Lehigh Valley Creosoting Plant at Perth Amboy, and was given entire charge of the operation of the plant, in addition to his duties as Assistant Engineer. This plant was among the earliest of the kind to be operated by an American railroad. The plant was abandoned some years later, but Mr. Berg, through his studious habits, became an authority on the creosoting process.

On November 1, 1887, he was appointed Principal Assistant Engineer, with office at Jersey City, for the extension of the Lehigh Valley Lines east of South Plainfield and the development of its water-front properties. In this capacity he constructed the double-track road from South Plainfield to the Jersey City Terminal, and designed and constructed the first piers now in use at the latter point. This latter work was a sample of his originality in design, especially the pier layout, by means of which a large amount of slip room was procured in the face of limited width of water-front, the piers being placed on an angle.

On December 1, 1898, he was made Engineer Maintenance of Way of the Lehigh Valley Railroad, at South Bethlehem, and a few months later was given charge of both Engineering and Maintenance of Way Departments.

On February 1, 1900, he was made Chief Engineer of the Lehigh Valley Railroad, in charge of construction, which position he held at the time of his death.

As Chief Engineer, he designed and constructed the large railway shop system at Sayre, Pa., including a large reservoir system used in connection with the same, in which work several phases of his individuality and constructive ingenuity are evident; he also made elaborate studies for elimination of grade crossings through the various cities; made exhaustive studies for present and future harbor improvements at Buffalo and New York, involving the solution of difficult problems; made studies and designs for large terminal yards, not only covering the present needs of actual service, but looking toward the future, which plans are now being followed in actual construction.

The achievements and brilliancy of Mr. Berg's career in the engineering profession conformed with the record he made while a student at college, where his adaptability, studious habits and exceptional intellect were evidenced by his having proof-read German publications, instructed in mathematics, and by his high scholarship.

Mr. Berg had the unusual combination of executive ability and breadth of view with faculty of closest attention to details, working out with his subordinates the minutest detail of any design. He also possessed a wonderfully analytical mind, and always analyzed a subject exhaustively before reaching a conclusion or reporting on the same.

By reason of his remarkable industry, analytical mind and engineering ability, he was frequently engaged with one matter or another outside of his regular vocation, and was often called upon by other companies and individuals to pass upon plans and give advice and otherwise act in a consulting capacity.

One of his novel achievements as a Consulting Engineer was the construction of the freight yard of the Harlem Transfer Company in the Bronx, New York City, whereby a small, ill-shaped piece of city property was economically developed by means of a circular freight house and circular tracks, the idea originating with Mr. Berg. This design proved highly successful and has since been used by the Lehigh Valley at its One Hundred and Forty-ninth Street Terminal, New York City.

Mr. Berg's career has been suddenly closed, but few men during fourscore years or more, in similar walks of life, have accomplished so much as he in his comparatively short career. The inherited influences which tended to develop his peculiar traits, and undoubtedly his rare genius in exact sciences, came from the substantial English ancestry, but his fine artistic tastes came from the foreign strain.

He was by nature kindly and genial, inspiring the respect of all with whom he came in contact, and courteous in his bearing always. While he stood upon an eminence professionally reached by but a select few, he will be missed not alone by those of equal or similar attainments, but more especially by those among the lower ranks of

the profession, to whom he was ever ready to extend a willing hand, give wise counsel and assistance in reaching a higher plane of usefulness, and this was true as well in his relation to those with whom he worked and walked in his daily life, outside the sphere of professional activities.

He was loyal to obligations and responsibilities assumed in the work of the several scientific and professional organizations to which he belonged, in all of which he became an effective force and leader. His habit of mind, his industry, his sound judgment, and his practical conclusions on all topics submitted to his analysis, made him an invaluable addition to the working force in any organization.

He was an author of note, and was a frequent contributor to the engineering magazines. Among the publications which stand as monuments of his discriminating, practical sense, as well as of his literary talent, are his voluminous work on "Buildings and Structures of American Railroads," issued in 1892, and still standing as the single comprehensive work in its special field, and a treatise on "Railway Shop Systems," published in 1904. He also compiled from the Proceedings of the Association of Railway Superintendents of Bridges and Buildings, a book on "Bridges and Buildings of American Railroads," and from other sources he gathered data for a work published under the title of "Berg's Timber Tests." His paper on "Education of Railroad Men for Subordinate Positions of Responsibility," written for the New England Roadmasters' Association, in the year 1900, and his paper entitled "Classification of Maintenance of Way Accounts," which was published in the fifth volume of Proceedings of the American Railway Engineering and Maintenance of Way Association, as well as others which might be mentioned, are of lasting value. While an officer of the Association of Railway Superintendents of Bridges and Buildings he personally edited the stenographic reports of discussions for the Proceedings of that Association, and the excellent form and condition of those records are due largely to his labor and judgment.

Mr. Berg became a member of the American Railway Engineering and Maintenance of Way Association on July 1, 1899, being one of the charter members. He became the first Chairman of the Committee on Buildings, and the report published in Volume 1 of the Proceedings was prepared by him, and that report indicates his grasp of the underlying principles which appealed to him as the groundwork for committee organization. In that report he inculcated the principle of individual effort and individual initiative in committee work, and it was practically the forecast of methods since pursued in carrying on the work of the standing committees. The following extract is worthy of place here:

"Each member should be asked for his preference in the choice of subjects, giving first, second and third choice. The assignment of subjects could then be made with reasonable certainty that each

subject would be handled by an expert, or at least the work be one of pleasure, with corresponding profitable results to the Association at large. As the general principle underlying the Association's work is the collecting, classifying, systematizing and disseminating of engineering information connected with railroad work, and not the aim to create official standards sanctioned by official representative votes, the work will be largely dependent upon the enthusiasm displayed by the individual members of the Committee, more particularly the sub-chairmen. Success will be proportionate to the care shown in the choice of the proper men to handle the various subjects."

Mr. Berg was made Vice-Chairman of the Committee on Records, Reports and Accounts, at the fourth annual meeting in 1903, and rendered efficient work in that position. He was elected a Director in March, 1904. At the fourth annual meeting in 1903, Mr. Berg made the first specific suggestion regarding the compilation of conclusions of the several standing committees, and of the definitions adopted by the Association in proper form for publication, as the recommended practice of the Association. He became an active member of the Publication Committee of the Board of Direction, and took special interest in the preparation of the data which had accumulated in the form of definitions, specifications and principles of practice; the subsequent issue of the Manual, in the admirable form we find it, was very largely due to his special care and to his genius in editing and compiling matter which it contains. His conscientious thoroughness in the preparation of plans, reports and all matters for which he assumed to be responsible, was manifested in all the work performed by him as a member and officer of the Maintenance of Way Association.

His remarks at the closing session of the ninth annual meeting reflect with great clearness his theory of the organization, of which he had just been made the executive head, and indicated at once his modesty in the assumption of important duties, and his generosity in his conceptions of his relation to those associated with him. The closing hours of the ninth annual session were for him the beginning with marked energy of that tenth administration of the office which it was his hope he might have filled throughout its term for the well-being of the whole Association.

In the preparation of the lists of the Committees for the coming year he took a very active part, and he gave an impetus to the work of the Association, in the brief period while he lived as its President, which gave great promise.

The organization of the important Committee on Rail received his particular attention, and on the day of his death, of which there was no premonition by reason of impaired physical conditions, he was preparing to leave for Washington to represent the Association at the conference called by President Roosevelt on the Conservation of our Natural Resources.

In 1893 Mr. Berg was married to Miss Ruby Burke, of Jennings, Va. Mrs. Berg died in November, 1904. Two children survive them, Walter G., Jr., ten years old, and Moncure B., three and a half years old. He is also survived by his mother, sister and two brothers. One of his brothers, Louis D'Coppet Berg, is a well-known architect of New York City; the other, Albert Ellery Berg, is a writer and dramatic critic. His sister, Lillie D'Angelo Berg, is a teacher in one of the musical conservatories.

Mr. Berg, in addition to being a member of the American Railway Engineering and Maintenance of Way Association, was a member of the American Society of Civil Engineers, member of the American Roadmasters' and Eastern Maintenance of Way Associations, Past-President of the Association of Railway Superintendents of Bridges and Buildings, member of the Railway Superintendents' Association, member of the Society for the Promotion of Engineering Education, member of the American Society for Testing Materials, member of the New York Railroad Club, member of the Founders and Patriots of America, and member of Holland Lodge, F. & A. M.

Mr. Berg's funeral was held at St. Paul's Episcopal Church, New York City, on May 14. In respect of his memory, the Lehigh Valley offices were closed, and the very large attendance of its officers and his associates was an expression of the sense of loss sustained by those with whom he had been associated for a quarter of a century. To them his departure meant much more than the mere loss of an official of a corporation. He was to them both a friend and a mentor, and as a superior officer in his department won admiration for acknowledged supremacy in his profession, and obtained the entire confidence of his office staff and subordinates by courtesy and fairness, and by his kindly interest in the welfare of the individual.

The railway which he served with such fidelity for so many years, the various associations, scientific and social, to which he gave so much of the best that was in him, and his friends in every walk of life, will forever cherish his memory.

Daniel Dawson Carothers

A Memoir.

Daniel Dawson Carothers, Director and Chairman of the Committee on Rail of the American Railway Engineering and Maintenance of Way Association, died at his home, Earl Court, Baltimore, Md., January 2, 1909.

He was born at Cutler, Washington County, Ohio, on August 21, 1860, and was the fifth son and seventh child of Rezin Dawson and Elizabeth Bain (Dawson) Carothers. His father in early life had been a millwright, but later became a railroad contractor. He had a fine mechanical turn of mind, which his son inherited, and he was noted for his determination and energy. His ancestors had come to America from Scotland, in colonial days, and settled in Huntingdon County, Pennsylvania. Mrs. Rezin Carothers was of English extraction, her ancestors having emigrated from England to Maryland, subsequently moving to Beaver County, Pennsylvania.

The early life of Daniel Dawson Carothers was passed on a farm, where he was required to do the "chores" and the odd bits of work which fall to the common lot of a country boy. This early experience had a tendency to develop both mind and body, and the boy showed a strong liking for work with tools and for everything which pertained to machinery. His mother exerted a strong influence over his early life and intellectual development, giving him his primary schooling, as the neighboring country schools, in those days, were poor and the terms of study of short duration. The last year or two of Mr. Carothers' school life was spent at Bartlett Academy; later he went to the National Normal University at Lebanon, Ohio, where he took a special course in engineering. During the last three years of Mr. Carothers' college life he taught school during the winter months.

In 1882 he began his labors in the field which he had chosen for his life work. His father was at that time connected with the Wheeling & Lake Erie Railroad, and the young civil engineer was given employment as a rodman under his father, who early impressed upon him, as the primary element of success in business, the commendable spirit which "always obeys orders." As a Rodman and Assistant Engineer, Mr. Carothers remained with the Wheeling & Lake Erie Railroad until 1883.

In 1883 he entered the service of the Columbus & Cincinnati

Prepared by I. G. Rawn, R. N. Begien, L. C. Fritch, J. E. Greiner, Francis Lee Stuart, A. W. Thompson.

Midland Railroad (now a part of the Baltimore & Ohio Railroad System), serving it as Assistant Engineer, Chief Engineer and Trainmaster, respectively. He remained with this company for seven years, or until 1890, when he transferred the field of his activity to the Baltimore & Ohio Railroad, with which company, or its subsidiary lines, he remained up to the time of his death.

In 1890 Mr. Carothers entered the service of the Baltimore & Ohio Southwestern Railroad as Engineer Maintenance of Way, which position he held until 1901. During this period he was engaged upon the reconstruction of the Baltimore & Ohio Southwestern's Mississippi Division, between Cincinnati and St. Louis, consisting of grade reduction and change in alinement of 340 miles of road. In this work he exhibited a rare quality of genius and good judgment, and established a record for this class of improvement, which at that period was a pioneer piece of work of like nature in the Middle West.

In 1901 he became Superintendent of the Chicago Division of the Baltimore & Ohio Railroad, with headquarters at Chicago. In this position he transferred his activity and qualifications to the Transportation Department, and his success in this work is borne out by the results attained through his efforts in adjusting the many complex terminal problems at Chicago which he was called upon to solve for his company during his administration there.

In 1903 he was made General Superintendent of the Baltimore & Ohio Southwestern Railroad, with headquarters at Cincinnati. His success in the administration of the Transportation Department at Chicago resulted in his promotion as General Superintendent, a position which was peculiarly to his liking in many respects.

In 1904 he was chosen Chief Engineer of the Baltimore & Ohio Railroad, with headquarters at Baltimore, Md., which position he held at the time of his death.

Entering the service of the Baltimore & Ohio Railroad on the eve of a new era in railroading in America, at a period when many railroad companies were making such marvelous strides in the way of development, Mr. Carothers played an important part in the upbuilding of one of the greatest railroad systems in the country. During the years he filled the many important positions to which he was chosen prior to 1904, he was instrumental in directing much of the energy that was then expended in railroad improvement.

Mr. Carothers brought to the position of Chief Engineer a broad experience in railroading as well as a high degree of engineering skill. At the outset the great Baltimore fire destroyed the general offices of the Baltimore & Ohio Railroad Company, but through his personal energy the records of his office were saved. He at once started the plans for the beautiful general office building, which he afterward constructed.

Perhaps one of the greatest pieces of work constructed under Mr. Carothers' direction was the Union Station at Washington, D. C.,

and the Terminal improvements at the same point. He was greatly interested in this work, and gave to the smallest details his personal attention.

Other examples of his skill in railroad engineering are the new Terminal at Wheeling, W. Va., and the great yard at Brunswick, Md.

Mr. Carothers' experience as an operating officer was varied, but he always referred to his service on the Columbus & Cincinnati Midland as the most valuable experience to himself. There he was both engineering and operating officer, giving orders and executing them personally, and it was that position which developed the ingenuity for which he was noted.

Every man who was ever associated with Mr. Carothers loved and respected him. Many men well and favorably known in the railroad world owe a great measure of their success to his kindly guidance and thoughtful help. It was his greatest pleasure to develop a man, and he often said that it was as creditable to develop a good man as it was to be one.

Mr. Carothers was a man of pleasing personality, and typified not only a successful engineer, but a success as a man. As an engineer and railway official he had initiative power, and his education and long experience, backed up by one of his most dominant characteristics—common sense—gave great strength to his views among other men of his profession. The men that worked in close touch with him were the men that appreciated and respected his opinions most. As a man, his sterling qualities and manliness drew everyone to him. Notwithstanding the position in the railway world that he had made for himself, those who knew him felt that this was but the beginning of his true usefulness, and they all feel a deep sense of personal loss at his death.

Mr. Carothers was married on September 20, 1888, to Miss Carrie Leland, of Lewiston, Me. They had one child, a son, who lived only a short time. Mr. Carothers resided during the years of his connection with the Baltimore & Ohio Southwestern Railroad at Cincinnati, where he had a large circle of social and business friends. He had often expressed the wish that upon his death he should be laid to rest in the family burial lot in beautiful Spring Grove Cemetery, beside the grave of his beloved infant son. Only a few weeks before his death he visited that sacred spot, and it was his custom on each visit to Cincinnati to take the time from his busy life to visit the cemetery and place a floral tribute on the grave of his loved one. He little knew, upon his last visit there, in how brief an interval he also would be laid to rest by his sorrowing family and friends. And here at last, even within the sound of the busy whirl of activity where he spent so much of his useful life, he rests from life's labors.

Mr. and Mrs. Carothers resided in Baltimore during the past five years, and have made many warm friends. Mr. Carothers was a member of the Maryland, Merchants', Baltimore Yacht, Baltimore

Country and Engineers' Clubs, of Baltimore; of the St. Louis Railway Club; of the Western Railway Club, of Chicago; of the American Railway Association; of the American Society of Civil Engineers; of the Ohio Society of New York, and of the Madisonville (Ohio) Lodge of Masons. He was a Charter Member and Director of the American Railway Engineering and Maintenance of Way Association, Chairman of its Rail Committee, and a member of the Special Committee on Conservation of Natural Resources, and attended the two conferences of the Governors of the States with the President of the United States at Washington.

"The world was better because he lived;
A noble spirit has gone to rest."

COMMITTEE
REPORTS AND DISCUSSIONS

REPORT OF COMMITTEE NO. XII—ON UNIFORM RULES, ORGANIZATION, TITLES, CODE, ETC.

(Bulletin 106.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee was instructed to report on the following subjects by the Board of Direction:

(1) *Supplement "General Rules for Government of Employés of the Maintenance of Way Department."*

(2) *Prepare Special Rules for Foremen and other employés, properly grouped and classified in accordance with and supplementary to the General Rules heretofore adopted.*

The Committee has held two meetings at Chicago, the first on July 3d, the members present being R. C. Barnard, G. D. Brooke, C. N. Kalk and J. A. Peabody; the second meeting was held on September 28th, R. C. Barnard, C. N. Kalk and C. A. Wilson being present. J. O. Osgood, W. H. Grant and R. L. Huntley were represented by correspondence.

The report presented to the ninth annual convention embodied Rules Governing Supervisors of Signals (see pp. 29, 30, Vol. 9, 1908), which were adopted by the Association.

Your Committee has no changes to recommend in previous reports adopted by the Association and now appearing in the Manual of Recommended Practice. The following additions are submitted for incorporation in the "General Rules":

"Anything that interferes with the safe passage of trains at full speed is an obstruction.

"Employés must exercise the greatest care and watchfulness to prevent injury or damage to persons or property; in case of doubt, they must take the safe course and run no risk.

"Co-operation is required between all employés whose work or duties may be jointly affected."

In accordance with the instructions given the Committee, a series of rules governing Track Foremen, Bridge and Building Foremen, and Signal Foremen have been formulated, and are submitted herewith for approval:

RULES GOVERNING TRACK FOREMEN, BRIDGE AND BUILDING FOREMEN, AND SIGNAL FOREMEN.

TRACK FOREMEN.

(1) Track Foremen shall report to and receive instructions from the ....(Title.)............

(2) They shall be responsible for the proper inspection and safe condition of the track under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

(3) They must go over their sections, or send a reliable man, at least once a day, to make a thorough inspection to see that the track, signals, culverts, bridges, fences, etc., are in safe condition.

(4) If the track or any bridge or culvert, in the judgment of the Track Foreman, is not safe, he must at once put out the proper signals to warn approaching trains and immediately notify the ....(Title.)............ of its condition, and do all in his power to repair the defect.

(5) During heavy storms, whether by day or night, whereby the track or any portion of the company's property becomes liable to damage, foremen and trackmen must be on duty; and at such times they must go over their sections to make sure that the track is safe, taking danger signals with them.

(6) They must use constant care to see that all waterways are kept free from obstructions.

*(7) They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains, and trackmen must protect themselves as prescribed by the Book of Rules. They must provide themselves with reliable watches, and compare time daily with a standard clock or with conductors.

†(8) In case of accident, they must at once render all assistance in their power, whether the accident occurs on their own or on an adjoining section.

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*Amend rule 7 to read: "They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains, and trackmen must protect themselves as prescribed by the Book of Rules. They must provide themselves with reliable watches, and when possible compare time daily with a standard clock or with conductors' watches."

†Amend rule 8 to read: "In case of accident, they must at once render all assistance in their power, whether the accident occurs on their own or on other sections."

*(9) They must permit no encroachment upon or occupancy of any portion of the company's right-of-way, except by proper authority.

(10) They shall employ such men as the ....(Title.)......... will direct, and see that they properly perform their duties. They must keep the required record of the time of their men and of the material used.

(11) They must keep a careful lookout for fires along the track, and prevent, if possible, the destruction of fences, wood or other material, and the spread of fire into adjoining fields. During dry weather they must not permit fires to be started unless they have sufficient force to keep them under control.

†(12) They must keep the vicinity of all bridges and trestles cleared of all combustible material, such as chips, bark, dried grass, etc. They must keep bridge seats, tops of piers and bottom chords cleaned of all cinders and dirt. Where water barrels are furnished, they must keep them filled with water.

(13) They must limit the use of handcars to the service of the company; and they must not permit anyone except employés of the company engaged in the performance of duty to ride thereon, except by proper authority. They must not permit the running of hand or velocipede cars belonging to private parties over the tracks of the company, except by proper authority.

BRIDGE AND BUILDING FOREMEN.

(1) Bridge and Building Foremen shall report to and receive instructions from the ....(Title.)...............

(2) They shall be held responsible for the proper inspection and safe condition of the structures under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

‡(3) They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their district. They must provide themselves with reliable watches, and compare time daily with a standard clock or with conductors.

*Amend rule 9 to read: "They must permit no encroachment upon or occupancy of any portion of the company's right-of-way and station grounds, except by proper authority."

†Amend rule 12 to read: "They must keep the vicinity of all bridges and trestles cleared of all combustible material, such as chips, bark, dried grass, etc. They must keep bridge seats, tops of piers, and all other readily accessible portions of bridges and trestles cleaned of all cinders and dirt. Where water barrels are furnished, they must keep them filled with water."

‡Amend rule 3 to read: "They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their district. They must provide themselves with reliable watches, and when possible compare time daily with a standard clock or with conductors' watches."

(4) They shall employ such men as the ....(Title.) will direct, and must see that they properly perform their duties. They must keep the required record of the time of their men and of the material used..

SIGNAL FOREMEN.

(1) Signal Foremen shall report to and receive instructions from the ....(Title.)..................

(2) They shall be responsible for the proper condition of signals and interlocking plants under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

*(3) They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their territory. They must provide themselves with reliable watches, and compare time daily with a standard clock or with conductors:

(4) They shall employ such men as the ....(Title.).......... will direct, and must see that they properly perform their duties. They must keep the required record of the time of their men and of the material used.

(5) In case of accident affecting any portion of the signal or interlocking apparatus under their charge, they must at once proceed to the spot with the men, tools and materials necessary to make repairs.

(6) They must investigate and report on the forms provided for the purpose all failures of signals and interlocking plants in their territory.

CONCLUSIONS.

(1) Your Committee recommends the adoption of the additions to the "General Rules" for publication in the Manual of Recommended Practice.

(2) Your Committee recommends the adoption of the Rules Governing Track Foremen, Bridge and Building Foremen, and Signal Foremen for publication in the Manual of Recommended Practice.

Respectfully submitted,

R. C. Barnard, Superintendent, Pennsylvania Lines, Cincinnati, O., *Chairman.*

F. L. Nicholson, Engineer Maintenance of Way, Norfolk & Southern Railroad, Norfolk, Va., *Vice-Chairman.*

G. D. Brooke, Assistant Engineer, Baltimore & Ohio Railroad, Pittsburg, Pa.

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*Amend rule 3 to read: "They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their territory. They must provide themselves with reliable watches, and when possible compare time daily with a standard clock or with conductors' watches."

W. H. Grant, Manager of Construction, Canadian Northern Railway, Toronto, Canada.

R. L. Huntley, Chief Engineer, Union Pacific Railroad, Omaha, Neb.

C. N. Kalk, Chief Engineer, Wisconsin Central Railway, Chicago, Ill.

G. L. Moore, Chief Engineer, Rutland Railroad, Rutland, Vt.

J. B. Myers, Division Engineer, Baltimore & Ohio Railroad, Cumberland, Md.

Jos. O. Osgood, Chief Engineer, Central Railroad of New Jersey, Jersey City, N. J.

J. A. Peabody, Signal Engineer, Chicago & Northwestern Railway, Chicago, Ill.

J. H. Wallace, Assistant Chief Engineer, Southern Pacific Company, San Francisco, Cal.

C. A. Wilson, Chief Engineer, Cincinnati, Hamilton & Dayton Railroad, Cincinnati, O. *Committee.*

The undersigned approves the report, with the exception of Rule (3), under Track Foremen, exception being taken to the authority given Track Foremen to delegate the daily inspection of track to another man.

G. H. Webb, Chief Engineer, Michigan Central Railroad, Detroit, Mich.

DISCUSSION.

Mr. R. C. Barnard (Pennsylvania Lines):—Mr. Chairman, the report of the Committee on Uniform Rules is to be found in Bulletin 106. There seems to me to be no necessity for my taking up the time of the convention in making any preliminary remarks in regard to our report. The Committee was instructed, as you will notice from the report, first, to supplement the General Rules for the Government of Employés of the Maintenance of Way Department, and, secondly, to prepare special rules for foremen and other employés, properly grouped and classified in accordance with and supplementary to the general rules heretofore adopted. Your Committee has complied with the first by submitting the three general rules that are to be found near the foot of page 4, and with the second by offering for your consideration rules governing Track Foremen, Bridge and Building Foremen, and Signal Foremen, which takes up the rest of the report and covers the sub-departments for which rules have heretofore been adopted by the Association.

It might be well to say that the greatest difficulty this Committee has encountered has been in determining where to draw the line between rules that are sufficiently in detail to cover all the essential points in this department, and still be applicable to the majority of roads members of this Association, and to exclude such less important rules as you generally find in the small books issued by the various roads for the government of maintenance of way employés, and it may be that the Association will consider that we have not drawn the line in the proper place and have gone too much or too little into detail.

The President:—The report is before you. The Secretary will read the clauses intended for addition to the "General Rules," and it will be taken for granted that unless there is objection they will stand approved as read.

The Secretary:—The following additions are submitted for incorporation in the "General Rules":

"Anything that interferes with the safe passage of trains at full speed is an obstruction.

"Employés must exercise the greatest care and watchfulness to prevent injury or damage to persons or property; in case of doubt, they must take the safe course and run no risk.

"Co-operation is required between all employés whose work or duties may be jointly affected."

The President:—There being no objection to allowing these three clauses to be incorporated in the "General Rules" and in the Manual of Recommended Practice, they will be so included.

We will next take up the rules governing Track Foremen, Bridge and Building Foremen and Signal Foremen. The Secretary will read the rules, and as they are read they will be considered adopted, unless there is objection.

The Secretary:—"(1) Track Foremen shall report to and receive instructions from the ....(Title.)..................

"(2) They shall be responsible for the proper inspection and safe condition of the track under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

"(3) They must go over their sections, or send a reliable man, at least once a day to make a thorough inspection to see that the track, signals, culverts, bridges, fences, etc., are in safe condition."

Mr. L. C. Fritch (Illinois Central):—I think the word "safe," in the last line, ought to read "proper condition." It is the duty of the inspector to see that the condition is proper, as well as safe.

The President:—Does the Committee accept that amendment?

Mr. Barnard:—Personally, I like what we have better.

The President:—Mr. Fritch, do you make a motion to that effect, to change that word or insert the word "proper"?

Mr. L. C. Fritch:—I move that the word "safe" be changed to "proper."

Mr. M. L. Byers (Missouri Pacific):—I move to amend by striking out the word "safe." That will give a proper reading and accomplish the same purpose.

The President:—Does the chair understand it is simply leaving the word "safe" out and to read "in condition"?

Mr. M. L. Byers:—Yes, sir; that will make it read, "for the proper inspection and condition."

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I would like to ask the mover of the motion if he would not make it read "safe and proper condition"?

Mr. L. C. Fritch:—It seems to me if it is in proper condition, it is in safe condition.

Mr. G. A. Mountain (Canadian Railway Commission):—It seems to me if it is in a safe condition for trains going over it, it is in proper condition.

The President:—There was no second to the amendment. We will take up the main question.

(Motion lost.)

The President:—The clause will stand as read. Has Mr. Webb anything to say?

Mr. G. H. Webb (Michigan Central):—I dissented to one clause there regarding Section Foremen being permitted to delegate their duties to somebody else. I do not think that is good practice, and I see they printed me as being in the minority regarding that clause in rule 3. On our road it is unnecessary for a Section Foreman to do

that unless he has taken it up in a special case with the Roadmaster for some definite purpose.

The President:—Any further discussion on clause 3? If not, the Secretary will pass on to rule 4.

The Secretary:—"(4) If the track or any bridge or culvert, in the judgment of the Track Foreman, is not safe, he must at once put out the proper signals to warn approaching trains and immediately notify the ....(Title.).......... of its condition, and do all in his power to repair the defect.

"(5) During heavy storms, whether by day or night, whereby the track, or any portion of the company's property becomes liable to damage, foremen and trackmen must be on duty; and at such times they must go over their sections to make sure that the track is safe, taking danger signals with them.

"(6) They must use constant care to see that all waterways are kept free from obstructions.

"(7) They must have a copy of the current time table, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their sections. They must carefully observe signals displayed by all trains, and assure themselves before obstructing track that all trains and sections due have passed. No notice will be given of extra trains, and trackmen must protect themselves as prescribed by the Book of Rules. They must provide themselves with reliable watches, and compare time daily with a standard clock or with conductors."

Mr. A. W. Johnston (New York, Chicago & St. Louis):—It seems to me there is a question there as to the requirement that the Section Foreman must provide himself with a reliable watch. We do not require that in the sense that we require them to have their watches examined, make it an absolute part of their duties under the rules. If, for some reason, he fails to provide himself with a reliable watch, and owing to that failure something happens to make the company liable, it may be a serious matter, and it is something that we ought to consider carefully.

Mr. E. R. Lewis (Michigan Central):—I move that the word "watches" be added after the last word "conductor." The revised clause would read: "Compare time daily with a standard clock or with conductors' watches."

Mr. Barnard:—That same thing occurred to me as the Secretary was reading it. The Committee will accept that.

Mr. C. E. Lindsay (New York Central & Hudson River):—The word "conductor," it occurs to me, is peculiar. We require our Supervisors to carry guaranteed watches and the Section Foremen are privileged to compare their watches with the Supervisor's watch.

Mr. Barnard:—The idea in preparing that rule was that the Supervisor might not be available every day and the Section Foreman

can always find some conductor on a train going by with whom he can compare his watch.

The President:—If there is no further discussion on rule 7 the Secretary will proceed with rule 8.

The Secretary:—"(8) In case of accident, they must at once render all assistance in their power, whether the accident occurs on their own or on an adjoining section."

Mr. E. R. Lewis:—I move that the word "adjoining" be changed to "or other." There are cases when the Foreman is called upon to go further away than an adjoining section.

Mr. Barnard:—The Committee accepts that suggestion.

The Secretary:—"(9) They must permit no encroachment upon or occupancy of any portion of the company's right-of-way, except by proper authority.

"(10) They shall employ such men as the..........(Title.)....... will direct, and see that they properly perform their duties. They must keep the required record of the time of their men and of the material used."

Mr. J. P. Snow (Boston & Maine):—I notice that all through this report the words "shall" and "must" are used irrespective of what they really mean. It seems to me that the word "shall" would be a better word to use all the way through. It would be more consistent if one or the other word were used invariably. The word "shall," it seems to me, would be preferable.

The President:—That matter has been discussed before in the convention. Heretofore it has been looked upon that there were some cases where more emphasis should be put upon certain rules than on others, and with that in view "must" was used as against the word "shall." What does the Committee think?

Mr. Barnard:—In our Committee meetings we have gone pretty thoroughly over the wording of this report and had, at those times, what we thought were good reasons for the wording that we used; I therefore do not like to say offhand that we will accept that general change.

Mr. Lindsay:—I would like to ask with regard to the first line, "they shall employ such men as the," etc., does that mean such number of men, or does that relieve the Foreman of the responsibility of employing the men, selecting the men—placing upon the officer, whose title is omitted, the responsibility, or does it mean such number of men or such kind of men?

Mr. Barnard:—Both.

Mr. Lindsay:—That relieves the Section Foreman of the duty of employing his own men.

Mr. Barnard:—The Section Foreman's chief will tell him how many men to put on his section and he knows from his general instructions what kind of men to employ, as to their physical ability, and so forth.

The Secretary:—"(11) They must keep a careful lookout for fires along the track, and prevent, if possible, the destruction of fences, wood or other material, and the spread of fire into adjoining fields. During dry weather they must not permit fires to be started unless they have sufficient force to keep them under control.

"(12) They must keep the vicinity of all bridges and trestles cleared of all combustible material, such as chips, bark, dried grass, etc. They must keep bridge seats, tops of piers, and bottom chords cleaned of all cinders and dirt. Where water barrels are furnished, they must keep them filled with water."

Mr. V. K. Hendricks (St. Louis & San Francisco):—I move that "floor beams and stringers" be added to that clause.

Mr. Barnard:—The only question that arises in my mind is, if you adopt that, where you are going to stop. You can go into more details and specify other things that they should be kept clear of.

Mr. Hendricks:—Then amend that by saying "all portions of steel bridges." I think all portions should be kept clean.

The President:—Mr. Hendricks, do you mean such portions of the bridge as come directly within the easy access of the Section Foreman?

Mr. Hendricks:—Yes, sir.

(Motion lost.)

Mr. C. H. Ewing (Philadelphia & Reading):—I would suggest that we eliminate the detail parts of the rule, for the reason that bottom chords are specified, and on the deck of the bridge the top chords are more accessible than the bottom chords. I would suggest that the rule read, "they must keep all accessible parts of bridges clear of cinders and dirt."

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I hardly think the gentleman expects a Section Foreman to climb up on top of top chords. That is accessible to a bridgeman, but not to a Section Foreman. It seems to me the idea of Mr. Hendricks was to require the Section Foreman to keep all parts of metal structures within reach without climbing free of cinders and dirt.

Mr. Snow:—I think the idea of Mr. Ewing is good; that is, leave out details. Whether the wording he suggested is best or not is somewhat questionable, but we cannot draw the line precisely where the Section Foreman shall leave off and the bridge crew come in. It would be better to cut out all reference to chords and confine the work to masonry, or else endeavor to draw a very precise line, which would be a difficult proposition if we cover all classes of structures. For instance, metal bridges have been spoken of. We do not want to confine the work to metal bridges. It should apply to all kinds of bridges, wood and everything. If we cut out the reference to bottom chords, and so forth, it seems to me it would be all right. I would suggest that to Mr. Ewing.

Mr. Barnard:—The Committee will accept that.

The President:—Is it understood, then, that it will read, "They must keep bridge seats, tops of piers, and so forth, cleaned of all cinders and dirt?"

Mr. Ewing:—Yes, sir.

The President:—It is so ordered.

Mr. L. C. Fritch:—It seems to me the words "and so forth" are too indefinite. Rules ought to be specific. We are leaving it too general by putting in the words, "and so forth." My preference is to leave the rule stand as it is.

Mr. M. L. Byers:—I ask if the Committee would accept the words "readily accessible portions" as a substitute for "and so forth"?

Mr. G. H. Webb:—The idea of putting that rule in was to keep the abutments, piers and bridge seats clean, and incidentally anything that might be resting on them, and as long as we cover the ground of keeping abutments, piers or mudsills cleaned off, we have accomplished what we started in to do. That is what the Committee had in mind.

Mr. McDonald:—I believe this discussion is out of order, but since the chairman permitted it, I want to state that I believe the vote was taken without a full understanding of the situation. I desire to record my protest against any rule which would relieve the Section Foreman of the duty of cleaning the locomotive sparks off of the ironwork of bridges. There is no more potent destroyer of ironwork by rust than these sparks in combination with water. It should be the duty of the trackwalker and sectionman to sweep these sparks off, and in my judgment their work should not be confined to sweeping off the masonry. It does not do much harm on the masonry, but it does do a lot of harm on the horizontal members of the steel structure.

Mr. Hendricks:—I second Mr. Byers' motion to make the sentence read, "they must keep bridge seats and tops of piers and all readily accessible portions of bridges cleaned of all cinders and dirt."

The President:—You have heard the motion to change rule 12 to make it read, "they must keep bridge seats, tops of piers and all readily accessible portions of bridges cleaned of all cinders and dirt." The motion is now before you.

Mr. L. C. Fritch:—It is as important to clean the trestles as it is the bridges, on account of the stringers or bottom chords of the trestles being of wood, and they should be cleaned just as well as these iron structures.

Mr. Barnard:—The Committee accepts the modification.

The President:—Is that acceptable to the seconder of the motion?

Mr. Hendricks:—Yes, sir.

The President:—The object is to put in the word "trestles," so as to make it read "bridges and trestles."

Mr. Snow:—Would not that be a repetition of what we started out with in the first line of the paragraph? It seems to me the first line covers that.

The President:— The rule says: "They must keep the vicinity of all bridges and trestles cleared of all combustible material," etc., and it was Mr. Byers' suggestion that "they must keep bridge seats, tops of piers and readily accessible parts of the bridges cleaned of all cinders and dirt."

Mr. Barnard:—I believe it was Mr. Byers' intention to leave in the words "bottom chords."

Mr. Byers:—I wish to have added after the words "tops of piers" the words "and all other readily accessible portions of bridges and trestles cleaned of cinders and dirt."

Mr. W. G. Brimson (Quincy, Omaha & Kansas City):—I suggest, in the place of the words "cinders and dirt," that we use the words "all foreign substances"—"cleaned of all foreign substances." At times of high water drift gets on the pier, and this remains on the pier as well as cinders and dirt. The Section Foreman might seek an excuse for not cleaning it off by saying they were twigs and branches of trees, etc.

The President:—As a rule, is not the ordinary foreman better acquainted with the term "cinders and dirt" than "foreign substances"? The Secretary will read the rule as it is to be amended.

The Secretary:—"(12) They must keep the vicinity of all bridges and trestles cleared of all combustible material, such as chips, bark, dried grass, etc. They must keep bridge seats, tops of piers and all other readily accessible portions of bridges and trestles cleaned of all cinders and dirt. Where water barrels are furnished, they must keep them filled with water."

The President:—All in favor of the amendment and the adoption of the clause as amended will say aye.

(Motion carried.)

The Secretary:—"(13) They must limit the use of handcars to the service of the company; and they must not permit anyone except employés of the company engaged in the performance of duty to ride thereon, except by proper authority. They must not permit the running of hand or velocipede cars belonging to private parties over the tracks of the company, except by proper authority."

Mr. Barnard:—It occurs to me that the rule would read more smoothly if we cut out the word "and" in the second line of the rule after the semicolon.

The President:—That is a question of phraseology, and that word will be cut out.

Mr. J. B. Berry (Chicago, Rock Island & Pacific):—I would like to go back to rule 9, after the words "company's right-of-way," and insert the words "and station grounds." Maintenance of Way employés draw a marked line as between the company's right-of-way and station grounds; if the matter is called to their attention I think they would pay more attention to it. If there is any one thing on the company's property that requires care from encroach-

ment it is at the station. I would make it read, "they must permit no encroachment upon or occupancy of any portion of the company's right-of-way and station grounds except by proper authority."

Mr. W. J. Burton (Missouri Pacific):—Would it not do just as well to make it "company's property" instead of "right-of-way," making it refer to any portion of the company's property?

Mr. Berry:—The company owns property sometimes quite a distance removed from the section through which the road travels, and what the Section Foreman is interested in is along his section. We might have a gravel pit, or something of that kind, located off the right-of-way.

The President:—The chair considers the point brought up by Mr. Berry as being in order.

Mr. Berry:—What I desire is that the rule shall read as follows: "(9) They must permit no encroachment upon or occupancy of any portion of the company's right-of-way and station grounds except by proper authority."

Mr. Barnard:—I have no particular objection to that, but are we not encroaching a little bit on the territory of the agent? I think the agent should keep people off his own station grounds. These are instructions for the Section Foreman.

Mr. L. C. Fritch:—It seems to me that is the very reason why it should be put in, because the Section Foreman thinks it is the duty of the agent to watch the station grounds, and if we put it in the rules, it makes it the duty of the Section Foreman. I think it is a very important matter, and hope it will be introduced into the rules.

Mr. Berry:—With all the care of the Section Foreman and station agent we are all of us losing property. I have known of many cases where people have been allowed to encroach upon railroad property, even business men in the town, and after the lapse of a few years claim it as their own.

The President:—All in favor of the adoption of the amendment say aye.

(Motion carried.)

The Secretary:—"Bridge and Building Foremen.—(1) Bridge and Building Foremen shall report to and receive instructions from the

.................................(Title.)...................................

"(2) They shall be held responsible for the proper inspection and safe condition of the structures under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

"(3) They must have a copy of the current timetable, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their district. They must provide themselves with reliable watches, and compare time daily with a standard clock or with conductors."

Mr. H. R. Safford (Illinois Central):—Rule 3 is only applicable to Bridge Foremen, and involves precautionary measures with reference to track construction, and it seems to me that the same features should be incorporated in that rule as appear in rule 7 under Track Foremen, and a motion is therefore offered that rule 3, under Bridge and Building Foremen, be amended, first, by eliminating the word "they" and substituting "Bridge Foremen" in the first line, and making the balance of rule 3 the same as rule 7 under Track Foremen.

Mr. A. W. Johnston:—As a matter of information, I ask why the Committee requires the Foreman to be familiar with the rules and regulations on the timetable. I can understand why a Section Foreman should be familiar with the timetable, as to the time of trains thereon, but if we are to inaugurate a system under which he should be familiar with all the rules and regulations on the timetable, and if he fails to be familiar with them, he should in some way be held responsible. Most of the rules and regulations on the timetable are for the government of the employes in train service and do not have to do with the duty of the Section Foreman, or particularly the Bridge Foreman, in his own work, and I think we should be careful not to put in a rule of this sort of phraseology which compels the employé to be familiar with rules which do not govern his own particular work.

Mr. L. C. Fritch:—It seems to me the word "familiar" there is not an impelling term. They ought to be familiar with these rules, and I think nearly every railroad company requires anyone who has to do with the movement of trains in any way to be familiar with the rules governing the movement of those trains, and I think, therefore, as the rule is worded, it would not make it absolutely compulsory.

Mr. L. A. Downs (Illinois Central):—The rule provides that they must compare time daily with a standard clock or with conductors. Sometimes on branch lines, or even on the main lines, the Bridge Foreman, or the Section Foreman, will go out to work on a bridge or on the road, and he cannot compare his watch with a standard clock or with a conductor's watch—it is not convenient for him to do so—and yet the rules state he must do it. I move that rule 3 be changed, also rule 7 under Track Foremen, to read that they shall provide themselves with reliable watches and compare time daily with a standard clock or with the watch of an employé whom they know has the correct time. We say "must" in that particular case, when it would be almost impossible to do it.

The President:—Suppose an instance be taken where they do not know that the man has the right time? What would be done in that case?

Mr. Downs:—They could not do it in either case. They can, however, almost always get the correct time from an agent—he got

the correct time the day before, and it is reasonable to suppose that he has the correct time. A flagman might go back from a train, and the Section or Bridge Foreman could ask him the time. I do not think we should limit it to a comparison with a standard clock or with the watch of a conductor.

The President:—On the particular branches you refer to, I suppose the standard clock would be the agent's clock?

Mr. Downs:—Not at all; the standard clock would be at some terminal point, and he would get the time and he would compare his watch with that. It is limited in this case as to where he can get the standard time from a conductor's watch or a standard clock, and it may be that he could not get it every day, and yet the rule says he must get it every day. I think that rule should be modified to permit him to use other methods to get the correct time.

Mr. Barnard:—I do not think that point is a particularly essential one, and it seems to me if we have a branch on which trains are so infrequent that a man cannot compare time with a conductor's watch once every day or two days, we will not spend much money on the maintenance of that branch.

Mr. Downs:—It does not say two days, but every day. The Bridge or Section Foreman may go out to his work and he may not see a conductor, except as they may go by on the train. He has no occasion to go where there is a standard clock, and possibly may not even go to the station. How, then, is he to compare his watch with some standard time? We should only put that in the rules that which it is possible for him to do.

Mr. Snow:—We are not obliged to compare the watch with the conductor directly—we are at liberty to do it indirectly, through a station agent, or some other means, or even by comparing the time with a brakeman. I believe the Committee's report should stand as it is in this respect, with the addition of the word "watches" as in rule 7.

The President:—Will Mr. Safford kindly repeat his motion?

Mr. Safford:—I move that rule 3 be amended by eliminating the word "they" at the beginning of the rule and substituting therefor the words "Bridge Foreman" and that the remainder of the rule shall be identical with rule 7, under the heading "Track Foremen."

Mr. Barnard:—What is the idea of changing the first word of that paragraph? The same word "they" appears throughout the rules. What is the reason for changing it in this one instance?

Mr. Safford:—The rule does not indicate it applies to Bridge Foremen exclusively.

Mr. L. C. Fritch:—It may apply to Building Foremen. A Building Foreman may be putting a coal chute over the main track, and in that case the Building Foreman should be as familiar with the rules and regulations on the timetable as the Bridge Foreman. I think the rule is correct as it stands, without the amendment.

(Motion lost.)

Mr. M. L. Byers:—I am very much in favor of making our rules of such a character that they can be rigidly enforced, and I agree thoroughly with Mr. Johnston's remarks on that subject. Therefore I move to amend the last sentence of this rule 3 by making the sentence read: "They must provide themselves with reliable watches and, when possible, compare time daily with a standard clock or conductors' watches."

Mr. L. C. Fritch:—I second the motion.

The President:—You have heard the motion, proposed by Mr. Byers and seconded by Mr. Fritch, to add the words "when possible" before the words "compare time daily with a standard clock or with conductors' watches."

(Motion carried.)

Mr. Downs:—Will that apply also to rule 7, under Track Foremen? It is the same thing.

The President:—In order to make it official, we will bring that before the house.

Mr. Downs:—I move that rule 7, under Track Foremen, be changed to read the same as rule 3, under Bridge and Building Foremen, in the same respect to the motion which has just been passed with reference to rule 3.

(Motion carried.)

Mr. Burton:—I would like to know the idea in not stating explicitly in this rule that Bridge Foremen shall protect the track when it is obstructed, the same as Section Foremen, and not to obstruct it excepting when trains are not due. Rule 7, under Track Foreman, has in it a clause which protects the track, while this rule does not have such a clause.

Mr. W. M. Camp (Railway and Engineering Review):—Does not rule 2 cover that point?

Mr. Barnard:—I agree with Mr. Camp that rule 2 covers that point.

The Secretary:—"(4) They shall employ such men as the ....(Title.).......... will direct, and must see that they properly perform their duties. They must keep the required record of the time of their men and of the material used.

"Signal Foremen.—(1) Signal Foremen shall report to and receive instructions from the ....(Title.)..........

"(2) They shall be responsible for the proper condition of signals and interlocking plants under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.

"(3) They must have a copy of the current timetable, and be thoroughly familiar with the rules and regulations thereon, and with the time of trains over their territory. They must provide themselves with reliable watches, and compare time daily with a standard clock or with conductors.

"(4) They shall employ such men as the ....(Title.).......... will direct, and must see that they properly perform their duties. They must keep the required record of the time of their men and of the material used."

Mr. W. J. Eck (Southern):—I would suggest to the Committee that there should be one additional rule provided to the effect that the Signal Foreman must not make any permanent rearrangement in signals or interlocking plants without proper authority.

Mr. L. C. Fritch:—I second the motion.

Mr. Barnard:—I think it is a good idea.

The President:—The Committee accepts the motion, and if there is no objection the Committee will embody it in their subsequent report.

The Secretary:—"(5) In case of accident affecting any portion of the signal or interlocking apparatus under their charge, they must at once proceed to the spot with the men, tools and materials necessary to make repairs.

"(6) They must investigate and report on the forms provided for the purpose all failures of signals and interlocking plants in their territory.

"Conclusions.—(1) Your Committee recommends the adoption of the additions to the "General Rules" for publication in the Manual of Recommended Practice.

"(2) Your Committee recommends the adoption of the Rules Governing Track Foremen, Bridge and Building Foremen, and Signal Foremen, for publication in the Manual of Recommended Practice."

Mr. L. C. Fritch:—I move that conclusions 1 and 2, as modified and amended, be adopted.

The President:—It is moved that the Committee's recommendations for publication in the Manual of Recommended Practice and the "Rules Governing Track Foremen, Bridge and Building Foremen and Signal Foremen," as amended, be adopted.

Mr. C. A. Paquette (Cleveland, Cincinnati, Chicago & St. Louis):—Before passing that motion, I would like to go back to the third paragraph of the general rules. The rule says, "Co-operation is required between all employés whose work or duties may be jointly affected." I think the word "among" should be substituted for "between."

Mr. Barnard:—I suggest that question be referred to Professor Pence.

The President:—The chairman of the Committee declines to take the responsibility, and suggests that Professor Pence might have a word to say about that.

Mr. L. C. Fritch:—It seems to me we are losing time on a small point like this. It is well known that according to grammatical rules two persons are concerned in "between," and more than two are concerned in "among."

Mr. Barnard:—While it may not be grammatically correct, it is common usage. I think it is the phraseology you generally see, and, I believe, proper.

Mr. L. C. Fritch:—It is incorrect, nevertheless.

Mr. Wendt:—Before this motion passes, I want to call attention to the fact that the rules which are approved for the Manual should be consistent with any work that has been done heretofore, otherwise the work done heretofore should be changed. Some two or more years ago the Track Committee submitted certain rules which were adopted under the heading of "Inspection of Track." They are found on page 66 of the Manual of 1907—six rules in all are included. Five of these rules relate to the duties of Section Foreman or Trackwalker, and the sixth rule relates to the duty of Supervisors.

I simply call attention to this matter, without making a motion, that the work which has now been submitted by the Committee on Uniform Rules should refer to, or modify, these rules on page 66 of the Manual. Rule 3 submitted to-day, under the head of "Section Foremen," relates to the duty of Section Foremen in connection with the inspection of the track each day. Rule 1 in the Manual, under the heading "Inspection of Track," suggests that except in cases of railroads of very light traffic the main track should be inspected each day by the section gang, or trackwalker. In that case we have approved the principle that except in cases of roads of light traffic the main track should be inspected either by the gang as a whole, or by a delegated trackwalker. There are no great inconsistencies between the two rules, but they should harmonize.

Furthermore, we might save some space in the Manual, and might save a repetition of words, if all rules commonly applicable to foremen, whether of track or bridges or buildings or signals, were grouped under one heading, that heading being "Foremen." In the rules now submitted there are differences of phraseology in the same rules where they are written for the three different classifications of foremen. Personally, I think that some time in the future we should group all rules generally applicable to foremen under one heading, these rules being such as pertain to safety of operation. Following that, we should have special rules for the different foremen relating to their special duties in connection with their methods of work. Furthermore, the rules should be supplemented in several respects; for illustration, the duty of track foremen in relation to the company's telegraph system is not definitely stated, and there are other features concerning which additional rules may be added in the future.

The President:—The chair, before putting the motion for the adoption of the rules, desires to say, in regard to one of the works which was uppermost in the late Mr. Berg's mind, namely, safeguarding the interests of the Manual, a work which was carried out by him very effectively, that the Board of Direction have appointed Mr. Edwin F. Wendt to continue that particular line of duty that Mr. Berg was so

eminently fitted for. It is no doubt an arduous task, but I am sure the Association recognizes Mr. Wendt's ability for taking charge of any hard and close work, and he will do so through the various sessions of this convention. The chair makes this announcement, because Mr. Wendt may have to take the floor quite frequently. Are you now ready for the question?

Mr. W. C. Cushing (Pennsylvania Lines):—I would like to say a word before the members vote on this, and that is that they should ask themselves the question: Will I make use of these rules when I go back home, in formulating my rules for the organization of a Maintenance of Way Department? It is a very pertinent question to ask, and it is our desire to have such matters in our Proceedings as we can stand by and make use of as much as possible.

(Motion carried.)

The President:—The recommendations of the Committee on Uniform Rules, as amended, have been adopted, and the Committee is excused with the thanks of the Association.

REPORT OF COMMITTEE NO. X—ON SIGNALING AND INTERLOCKING.

To the Members of the American Railway Engineering and Maintenance of Way Association:

During the past year your Committee on Signaling and Interlocking held meetings as follows:

March 18, at Chicago; present, Messrs. Anthony, Clausen, Hovey, Mock, Patenall, Peabody, Rhea, Stevens and Rudd, Chairman. Absent, Messrs. Ames, Balliet, Ellis, Scott, Taussig, Temple, Waite and Wendt.

May 13, 14 and 15, at Buffalo; present, Messrs. Ames, Anthony, Clausen, Christofferson, Ellis, Hovey, Mock, Patenall, Peabody, Rhea, Scott, Stevens and Rudd, Chairman, three days; Balliet, Taussig and Temple, two days; Wendt, one day. Absent, Messrs. Cable and Waite.

July 7, 8 and 9, at Detroit; present, Messrs. Ames, Anthony, Christofferson, Mock, Patenall, Peabody, Rhea, Stevens, Temple, Wendt and Clausen, Vice-Chairman. Absent, Messrs. Balliet, Cable, Hovey, Rudd, Scott, Taussig and Waite.

November 18 and 19, at Chicago; present, Messrs. Anthony, Cable, Christofferson, Ellis, Patenall, Rhea, Scott, Stevens, Temple and Vice-Chairman Clausen, two days; Messrs. Hovey, Mock, Peabody and Wendt, one day. Absent, Messrs. Ames, Balliet, Rudd, Taussig and Waite.

Sub-Committees were appointed as follows:

A—*Aspects:* Messrs. Mock, Rhea and Hovey, Chairman; later, Stevens substituted for Hovey, and Patenall still later for Rhea, and at the November meeting Messrs. Cable, Scott and Peabody were added to the Committee. As at present constituted, Messrs. Cable, Mock, Patenall, Peabody, Scott and Stevens, Chairman.

B—*Standard Contract:* Messrs. Stevens, Peabody and Rhea, Chairman.

C—*Switchstands:* Messrs. Clausen, Rhea and Mock, Chairman.

D—*Revision of Manual:* Messrs. Patenall, Wendt and Stevens, Chairman.

E—*To Confer with Committee No. XI on Symbols:* Messrs. Ellis, Hovey and Peabody, Chairman.

F—*Standard Designs:* Messrs. Anthony, Ellis—later substituted by Stevens—Patenall, Peabody and Mock, Chairman.

There were six subjects specifically assigned to the Committee, as follows:

(1) *Mechanical Interlocking Specifications.*

(2) *Electric Interlocking Specifications.*
(3) *Rubber-covered Wire Specifications.*
(4) *Prepare Standard Interlocking Agreement for Signal Work, Assigned to Sub-Committee B.*
(5) *Prepare Outline and Description of a "Comprehensive System for Uniform Signaling Suitable for General Adoption."*
(6) *Confer with Track Committee Relative to Switchstands, Assigned to Sub-Committee C.*
(7) *Revision of the Manual, Under General Instructions, Assigned to Sub-Committee D.*
(8) *Conference on Symbols, which is not printed in the Instructions to Committee No. X, but is covered under Instruction No. 2 to Committee No. XI.*

SUB-COMMITTEE A, SUBJECT NO. 5, ASPECTS.

This Sub-Committee made reports to the General Committee in May and July, and its report is included under Subject No. 5.

SUB-COMMITTEE B, SUBJECT NO. 4, STANDARD INTERLOCKING AGREEMENT.

PROGRESS REPORT.

One of the subjects assigned to Committee No. X for the year 1906-1907 was the preparation of a standard agreement covering the construction, renewal, maintenance and operation of joint interlocking plants and the proper apportionment of expenses incident thereto.

At the 1907 annual meeting a progress report was made, over which ensued considerable discussion, especially as to the proper division of operating expenses.

There was submitted and adopted in connection with this progress report a table of operated units and values of same as a basis for the division of construction, renewal and maintenance expenses. This should be expressed in more specific language and necessary additions provided, as follows:

TABLE OF OPERATED UNITS.

Name of Operated Unit.	*Value.*
Each signal arm working in two or three positions	1 unit
Each power signal arm working in two or three positions on mechanical plants, normal indication locking included	2 units
Each pair of switch points	1 unit
Each single slip switch (2 pairs of switch points)	2 units
Each double slip switch (4 pairs of switch points)	4 units
Each set of movable point frogs (2 pairs of frog points)	2 units
Each derail	1 unit
Each 55 ft. of detector bar with or without locks	1 unit
Each torpedo placer	1 unit

Each drawbridge coupler..1 unit
Each drawbridge rail surface and alinement lock for one pair of rails ....1 unit
Each drawbridge leveling and operating apparatus lock..........1 unit
Each track circuit..1 unit

HISTORICAL.

In the past the division of expense at joint interlocking plants, particularly those covering grade crossings, seems to have followed no clearly defined principles. There has been a growing tendency, however, in recent years, to divide all the expense on what is known as lever, function or operated unit bases, which might in brief be said to be an attempt to apply the principle that each company pays for what it gets.

An examination of the State laws and rulings of the various State Railroad Commissions does not provide us with any uniform method. In a number of cases Railroad Commissions have ruled on one of the above bases; in other instances it is difficult to determine the principle, if any, on which the orders have been based. In certain States the laws are considered by some to be inequitable to the new companies, and in others to the existing companies. At times the orders made have taken into account existing agreements; at other times such agreements have been wholly ignored. In some cases the orders have been made in line of the precedents established by former orders, and at other times the weight of precedent has been ignored. For these reasons your Committee believes it would be of material value for this Association to make recommendations based on correct principles.

PROPER BASIS.

Your Committee has endeavored to eliminate the relations of its members to their respective employing companies and consider the subject as they would if employed as experts. Assuming such a position, no doubt many bases of division might be given an argumentative hearing, but the test, which we have considered as conclusive, is as follows: the responsibility of all carriers in safeguarding and expediting traffic.

To properly consider all the various relations which arise, it seems best to make the following classification of agreements:

Class A.

Agreement covering the construction of an interlocking at an existing crossing where there may be or may not be agreements covering the renewal and maintenance of such crossing and the providing of crossing watchmen and watching facilities.

Class B.

Agreement covering the construction of the crossing of a new line with existing lines and the extension of an existing interlocking to protect the new crossing.

Class C.

Agreement covering the construction of a new crossing to be protected with interlocking.

This division into the above classes is necessary for the reason that the different types of situation require somewhat different treatment in each instance; for example, in Class "A" there may be existing agreements to which proper consideration should be given as bearing on the providing of fixed arbitraries.

The completeness of the installation, after certain primary requirements, is in a measure elective by each interested party, and the *construction, renewal* and *maintenance* expense is approximately proportional to the increase or decrease of the operated units. Therefore the expense for *construction, renewal* and *maintenance,* or the residue after proper consideration has been given to prevailing agreements, should be divided in the same proportions as the number of operated units assigned to the various companies bears to the whole number of operated units of the plant. Each percentage will then represent the actual ownership of an interested party and is the measure of its responsibility as a carrier. This basis of division, therefore, results approximately in each interested party paying directly as to the ownership and as influenced by its requirements, or, in other words, depends directly on what it gets.

As *operating expenses* are not directly or even approximately in proportion to an increase or decrease of operated units, the present tendency to use such a basis of division is neither correct in principle nor equitable in results. Neither is the *operating expense* even approximately affected by the amount of traffic handled and, therefore, a division of expense on a wheelage basis is not correct in principle nor would it be equitable as to results; in addition it would be bothersome and constantly changing on account of the variation in the volume of traffic.

As the signalmen must of necessity be considered as joint employés, and as the operation of an interlocking plant is not so much a question of the amount of work to be performed as of the fact that attendants must be on duty at all times, the most equitable division of operating expenses is, first, a proper consideration provided in the form of arbitraries as required by already existing agreements, and, second, the division of operating expenses, or such residue as is left after above treatment, into as many parts as there are interested parties. If, however, either party adds facilities that are for its exclusive benefit, and such additions then or at any future time add to the cost of operation, the party making these additions should bear the burden of such increase; as, for example, adding block signals and requiring operators instead of levermen when levermen only would be required to take care of the primary situation.

With the above in mind, your Committee submits herewith a draft of agreement Class "A," to be used as a guide for discussion. In some cases alternate paragraphs are suggested to cover different conditions which may exist.

SAMPLE AGREEMENT—CLASS A.

Preamble.

THIS AGREEMENT, made and entered into this ....day of ...., A. D., by and between the A and B Company, hereinafter called the X Company, party of the first part, and the C and D Company, hereinafter called the Y Company, party of the second part,

Witnesseth:

WHEREAS, the roads of the respective parties now intersect and cross each other at ...., as provided for in an agreement made and entered into the .... day of .... A. D., by and between the E and F Company of the first part and the G and H Company of the second part, of which the said X Company and said Y Company are the respective successors, and

WHEREAS, the parties are mutually desirous of erecting, renewing, maintaining and operating an interlocking plant at said crossing to facilitate and render more safe the passage of trains over the same, the location of said crossing being identified, and the said interlocking plant to be arranged as shown upon blueprint dated ...., identified by the signature of the .... Engineer of the first party, and the .... Engineer of the second party, attached hereto, marked Exhibit "A," and hereby made a part of this agreement, and

WHEREAS, the parties hereto have agreed upon the terms and conditions upon which said interlocking plant, as shown by said Exhibit "A," shall be constructed, renewed, maintained and operated;

Now THEREFORE, in consideration of the premises, and in further consideration of the mutual covenants and agreements hereinafter stipulated to be kept and performed, it is agreed between the parties for the purpose of defining the terms and conditions upon which said interlocking plant shall be constructed, renewed, maintained and operated, as follows:

First—The said X Company agrees to construct an interlocking plant as shown upon said Exhibit "A," and in accordance with the specifications to be approved by the above-named Engineers, under the operation of which trains of either party may, pursuant to the laws of the State of ...., pass over the tracks of the other party without coming to a stop. The cost of removing any existing safety devices or appliances shall be divided in like manner, as the cost of the former renewal and maintenance expense of said devices or appliances has been heretofore divided.

Second—The cost of constructing, renewing and maintaining said interlocking plant, as shown upon said Exhibit "A," shall be borne on

an operated unit basis by the parties hereto in the proportion that the total number of operated units used to interlock the tracks of each of the respective parties, bears to the total number of operated units of the complete interlocking plant, as shown by the table of operated units on said Exhibit "A."

Third—(a) The cost of operating said interlocking plant, as shown by said Exhibit "A," shall be borne equally by the parties hereto.

(b) The cost of operating said interlocking plant shall be borne as follows:

Said .... Company shall pay the sum of .... Dollars ($......) per month, the amount which it now pays for railway crossing watchmen, their supplies, and maintenance of railway crossing gates; the balance of said operating expenses shall be divided equally between the parties hereto.

NOTE.—(a) and (b) to be used as circumstances require.

Fourth—All extensions or changes of said interlocking plant arising from changes made in any existing track or tracks, or made to cover any future track or tracks or connections which either party may have the right to construct, or which may be required by reason of any changes made in the standard appliances of either Company, or ordered by proper authority, shall be made by said X Company and the first cost of such extensions or changes shall be borne by the party hereto for whose benefit said extensions or changes are made, and the amount chargeable for renewal and maintenance to each party in such case is to be determined by the proportion which the total number of operated units then used to interlock the tracks of each of the respective parties, bears to the total number of operated units of the complete interlocking plant.

Fifth—The renewal and maintenance of said interlocking plant shall be under the sole charge and control of said X Company, and it shall employ competent persons to renew and maintain the same, and such parties from time to time so employed shall be considered as joint employés of the parties hereto and shall be removed for good and sufficient reasons upon request in writing of the general managing officer of the said Y Company.

And it is further mutually agreed and understood that in event said Y Company shall in writing notify said X Company of renewals and repairs that may be necessary for the safe and proper operation of the said interlocking plant, and if said X Company neglects for a period of 30 days to make said necessary renewals and repairs, then said Y Company shall have the right to make such renewals and repairs, and said X Company, upon presentation of the proper bills therefor, will pay its proportion of the amount so expended.

Sixth—The operation of said interlocking plant shall be under the sole charge and control of said X Company, and it shall employ com-

petent persons to operate the same, and such persons from time to time so employed shall be considered as joint employés of the parties hereto and shall be removed for good and sufficient reasons upon request in writing of the general managing officer of the said Y Company; and it is further mutually understood that either Company may use the signalmen in its telegraph or telephone service, but in event additional expense is so incurred, on account of increased wages of operators over levermen, the Company using the operators in its service shall bear the additional expense.

Seventh—The salaries of employés connected with maintenance, renewal and operation of the interlocking plant shall be the same as the standard salaries paid by the X Company for similar service to its other employés in the territory of the said X Company's .... Division.

Eighth—The payment of all bills under this agreement shall be made not later than the twenty-fifth day of the month following the month in which said bills are rendered. The bill for expense of construction shall be made as a final bill, unless otherwise mutually agreed and understood. In the event that partial bills for expense of construction are rendered, each such partial bill shall not only show fully the part of the construction expense to be paid by such bill, but shall also include a statement of all construction expense which has been covered by any partial bills which may have been rendered and paid previously.

Ninth—In making bills for the cost and expense of construction, renewing and maintaining said interlocking plant, all labor and material shall be charged for at actual cost, plus .. per cent. added to material and .. per cent. to labor for handling, superintendence, use of tools and accounting.

The labor for the operation of said plant shall be charged for at its actual cost, without the addition of any percentage.

Note.—Your attention is called to the fact that no provision is made for the $5 monthly charge, provided for in the rules of the General Managers' Association of Chicago. Your Committee feels that this charge should be discontinued, for the reason that this is an organization charge.

Tenth—Each of the parties hereto, will, without cost to the other, furnish and install its own derails, switch rods, special switch and derail timbers, insulated track joints, cross-arms, pins and insulators, and will renew and maintain them from time to time thereafter; likewise, without cost to the other party, do all the trackwork and grading along its own tracks necessary to prepare the same for the installation of said interlocking plant, and will also provide and maintain proper drainage upon its right-of-way.

Eleventh—Each of the parties hereto will at its own expense keep all switches and derails in its own tracks free from ice, snow, dirt or

other obstructions which may interfere in any way with the proper working of said interlocking plant, and in case either party fails so to do, the other party shall have the right to enter upon the premises of the party at fault and remove such ice, snow, dirt or other obstructions, in which event the party at fault shall reimburse the party doing such work for all expense thereby incurred, plus .. per cent. to cover superintendence, use of tools and accounting.

Twelfth—Each party hereto shall pay for all loss, damage and expense caused by its separate agents or employés, either to the interlocking plant, to the property of the other party, or to others not parties to this agreement.

All loss, damage and expense caused by the individual negligence of employés connected with the construction, renewal, maintenance or operation of the interlocking plant, or by the combined negligence of such parties hereto, or by failure of any part of the interlocking plant, shall be borne and paid for by the party hereto that may be using the interlocking plant at the time such loss, damage and expense occurs, and, if same shall occur while the trains of both of the parties hereto are at the crossing, or shall be caused by the combined negligence of the separate employés of the parties hereto, each party therein involved shall bear and pay for all loss, damage, and expense caused to its own property, or to persons or property in its charge; all other loss, damage and expense caused as above shall be borne and paid for equally by the parties therein involved.

Thirteenth—It is further distinctly understood and agreed that any and all agreements relative to said crossing existing between the parties hereto, or their predecessors, so far as they conflict, or are inconsistent with the terms and provisions of this agreement, are hereby annulled, but in all other respects shall continue in force and virtue.

Fourteenth—Should any dispute arise between the parties to this agreement concerning obligations or rights of either of them hereunder, the same shall be referred to a board of three arbitrators, one to be chosen by each party hereto and the third by the two so chosen. If either party shall fail to appoint its arbitrator within fifteen (15) days after the party desiring arbitration has appointed its arbitrator, and given written notice to the other of such appointment and of the matter proposed to be arbitrated, then the arbitrator so appointed shall appoint an arbitrator for the defaulting party and the two so appointed shall appoint the third to complete the board as above provided, and said board so appointed shall hear and decide the dispute, and assess the expenses of arbitration. The decision of said arbitrators chosen in either of said ways, or that of a majority of them, shall be final and conclusive between the parties upon the matters concerning which arbitration was demanded.

Fifteenth—The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

IN TESTIMONY WHEREOF, the parties have caused these presents to be executed in duplicate by their respective proper officers as of the day and year first above written.

The A & B R. R. Company
By....................

Attest:

....
Sec'y.

....

(Seal.)

The C & D R. R. Company
By....................

Attest:

....
Sec'y.

....

(Seal.)

Your Committee submits the above as a Progress Report for the following reasons:

(1) The table of operated units and values being of a technical character, from a signal standpoint, should be considered and acted on by the Railway Signal Association; that Association fully completing table and assigning proper value to each operated unit.

(2) As a number of the points are to be covered for the proper protection at new crossings, on account of the growing use of electric traction and, as these are also matters of a technical nature, from a signal standpoint the best results will be obtained by having the Railway Signal Association take proper action, permitting of these provisions being incorporated in drafts of sample agreements B and C.

(3) It is felt that this Progress Report sufficiently develops the principles involved to permit of their full discussion and adoption of such conclusions as will definitely settle the bases for the proper division of construction, renewa', maintenance and operating expenses.

The Railway Signal Association has already taken in hand the consideration of the two points above-mentioned, and its action will no doubt be available for next year's report.

CONCLUSIONS.

(1) That existing agreements should be given due consideration in the form of arbitraries in the division of construction, renewal, maintenance and operating expenses.

(2) That the proper division of construction, renewal and maintenance expenses is on an operated-unit basis, each party paying for what is required to interlock its tracks, or the residue, where there are existing agreements requiring fixed arbitraries.

(3) The primary operating expense, or the residue after deducting such arbitraries as may be required by existing agreements, should be equally divided among the several parties interested. Where operating expenses are increased by facilities for the exclusive use of one party, such party for whose benefit such facilities are provided should pay the entire additional operating expense.

The entire Committee endorses these conclusions, and recommends the adoption of the report as a progress report, requesting discussion to bring out any points at variance with this report.

SUB-COMMITTEE C, SUBJECT NO. 6, SWITCHSTANDS.

Mr. L. S. Rose, Chairman of Committee No. V, on Track, advised that his Committee was not ready to handle the question of switchstands, which could go over until next year. In view of the fact that report on Aspects of Committee No. X is a progress report and not completed, your Committee No. X felt that it was not in a position to urge action this year. It is admitted, we believe, by Committee No. V, on Track, that part of a switchstand is a signal, and that Committee No. X should make a recommendation regarding the aspect of same, so that it will not conflict with the recommended uniform system.

SUB-COMMITTEE D, REVISION OF MANUAL.

In view of the fact that Committee No. X has not completed the Aspects for a Uniform System of Signaling, your Sub-Committee recommends that no changes in the Manual be made, except such as may be made necessary by the approval, on the part of the Association, of the specifications and standards submitted this year.

Committee No. X endorses the recommendation of Sub-Committee D.

SUB-COMMITTEE E, CONFERENCE ON SYMBOLS.

A meeting with Sub-Committee of Committee No. XI, on Records, Reports and Accounts, was arranged for February 22, but not held; meeting was held June 5. The result of this meeting was presented to General Committee No. X at Detroit in July, adopted, and, on July 10, blueprints of the revised symbols were forwarded to the Chairman of the Sub-Committee of Committee on Records, Reports and Accounts, with the statement that Committee No. X wishes it understood that the proposed symbols will be subject to change when the question of Aspects of Signals is completed.

SUBJECT NO. 1, MECHANICAL INTERLOCKING SPECIFICATIONS.

Specifications for Mechanical Interlocking and Material for Construction Work were adopted by this Association in 1907, they being the specifications adopted by the Railway Signal Association at its annual convention in 1906. Since that time a number of improvements have been made in signaling, and Standing Committee, known as Committee No. II, of the Railway Signal Association, has been at work revising these specifications and reconciling as far as possible their requirements with those of other specifications. The report follows:

REPORT ON PROTECTION OF DRAWBRIDGES, LIFT RAILS, ETC.

(Committee No. II—Railway Signal Association.)

The protection of train movements over drawbridges by interlocking is by no means a new departure in the signaling world, but very little progress has been made toward the establishment of uniform methods of application, the different methods in vogue having been considered good practice by all roads employing them.

The strides that have been made in the development of railway signaling devices in recent years are remarkable, but it is notable that until recently very little improvement has been made in the locking of drawbridges and lift rails, and it seems strange that in the midst of all the achievements in signal devices, that a matter of such obvious importance should have received such scant attention.

In connection with drawbridges (from a transportation standpoint) the points of least security are the lift rails at their junction with the shore rails, and as every consideration of safety demands that the track over the draw be as substantial as at any other point, we find the inevitable slow sign with its consequent interference with the up-to-date movements of trains as a result, and in numerous instances, a full stop, before crossing the draw, is deemed a necessary precaution.

In order to eliminate the conditions of least security, the lift rails should be connected in such a manner as to make it necessary for them to be in perfectly proper and safe position, both laterally and vertically, before they can be locked and signals given to proceed over the draw, and it is important that the locking device provided be of a simple and appropriate design so that its maintenance will introduce no complications.

It is also necessary to prevent the application of power for the purpose of withdrawing the bridge latch or opening the draw while the lift rails are locked and signals indicate proceed.

Having in mind the lack of uniformity as described in the foregoing, your Committee has endeavored to formulate such recommendations as would have a tendency to reduce to a minimum the number of different methods of application, but owing to the many different designs of drawbridges and methods of operation, we are unable to recommend any standard apparatus or methods of locking that would be suitable for all, and owing to the different requirements and conditions at different points, we cannot consistently recommend any uniform arrangement of signals, etc.

The Standard Specifications for Mechanical Interlocking submitted herewith, have been so rearranged as to apply to about all drawbridge interlocking installations so that we do not consider any special clause on this account necessary.

The following are the drawbridge recommendations which we would submit to the Association:

RECOMMENDATIONS OF COMMITTEE NO. II—ON INTERLOCKING PROTECTION OF DRAWBRIDGES.

SIGNALS.

Signals shall be provided for all routes approaching the draw and shall be located not less than 500 ft. from draw in direction of traffic, and 200 ft. from draw in reverse direction, un'ess State or Federal authorities prescribe otherwise.

High home signals with adequate approach information should be provided for current of traffic and dwarf signals for reverse and other routes approaching the draw.

LOCKING.

A locking arrangement shall be provided for each of the following purposes before signals can be cleared:

(a) To insure that the bridge is in proper alinement.

(b) To insure that all bridge surfacing devices are in their proper position.

(c) To lock each rail in proper position for train movement.

(d) To prevent the application of power for purpose of withdrawing bridge latch or opening draw.

NOTE.—The Committee considered the subject of suitable rail locks and on account of the different style of drawbridges it was deemed inadvisable to recommend any particular locking device and that each case would have to be taken up on its own merits.

REPORT ON SOME IMPROVEMENT IN FACING POINT LOCKS OR SOME DEVICE IN CONNECTION WITH THEM TO INSURE THAT SWITCH HAS RESPONDED TO THE POSITION OF THE LEVER.

Your Committee has carefully studied the subject of an improvement in facing point locks to detect a failure of switch having responded to the movement of the lever, but after exhaustive discussion, we are at this time unable to report having conceived anything practical in that line.

The only mechanical device which we consider effective is the so-called bolt lock, which is in reality a detector lock, and should be so known (so named). The bolt lock was designed and employed to detect the failure of switches, derails, movable point frogs, etc., failing to respond to the movement of the lever, and also to prevent the reversal of such switches, derails, movable point frogs, etc., until signal governing over them has been restored to the stop position.

Owing to the likelihood of an accident due to a misplaced movable facing point having disastrous results, it is the recognized practice to bolt lock them with unlimited and limited speed signals governing over them as far as practicable; but owing to the complications where a signal is made to govern two or more routes, it is often found impracticable to bolt lock all the movable facing points in each route, and

each situation must be considered on its own merits, and the best arrangement of bolt locking determined.

It is not the recognized practice to bolt trailing switches, as the facing point lock is deemed sufficiently reliable. Should a trailing switch be run through in the wrong position, derailments are not likely to result.

The Committee does not consider the safety, derived from bolt locking switches leading to high speed routes with slow speed and reverse movement signals, sufficient to warrant the expense and complication which their installation would entail.

When local conditions are such as to render the use of mechanical bolt locking impractical, either switch signal control, or electric locking, or both may be substituted; each situation being considered on its own merits, and the best arrangement determined.

CONCLUSIONS.

NOTE.—Where bolt locks are used, the following requirements will apply:

(a) Home signals for unlimited speed routes shall be bolt locked with all facing derails, switches, and movable point frogs in the route governed.

(b) Home signals for limited speed routes shall be bolt locked with all facing derails, switches, and movable point frogs in the route governed as far as practicable.

(c) All facing derails shall be bolt locked with all signals governing over them.

(d) Bolt locks shall be so constructed that the signal bar shall pass through the notch in switch bar to insure that switch is set in proper position and shall not be capable of passing through other notches that may be cut in the switch bar.

(e) The connections to the bolt lock bars shall be adjustable.

(f) The length of notch in signal bar shall be one and three-quarters (1¾) in. greater than the thickness of the switch bar. The length of the notch in the switch bar shall be five-sixteenths ($\frac{5}{16}$) in. greater than the thickness of the signal bar.

(g) The connections to signal bar in bolt lock shall be compensated where the changes due to temperature, spring and wear to connections, exceed the clearance of the notch in the signal bar.

NOTE.—Where automatic substitutes for bolt locks are employed.

(h) Circuit controllers shall be connected to all movable facing points in unlimited, and limited, speed routes with circuit controllers on their respective operating levers controlling electric locks on facing point lock levers.

(i) Where semi-automatic or power signals are used, the controlling circuits may be broken through circuit controllers on all movable facing points over which the signal governs.

TO EDIT AND BRING UP TO DATE REPORTS ALREADY MADE BY COMMITTEE NO. XV ON STANDARD SPECIFICATIONS FOR INTERLOCKING.

Your Committee in re-editing Standard Specifications for Interlocking has carefully considered, and was guided by, reports of previous committees, which had been adopted by the Association, and by standard practice now in vogue.

In order that Specifications for Mechanical Interlocking conform as nearly as possible to the electric specifications, we have copied the first nineteen paragraphs of the electric specifications, with the exception of changes in paragraphs marked with a star, and which have been either re-worded or added new.

The specifications from paragraph twenty to fifty-six inclusive are in accordance with the best known modern practice, and each paragraph was unanimously accepted by the Committee and by the supply men.

STANDARD SPECIFICATIONS FOR MECHANICAL INTERLOCKING AND MATERIAL FOR CONSTRUCTION WORK.

SPECIFICATIONS.

General.

1. Specifications.
2. Drawings.
3. Supervision.
4. Alterations.
5. Permits.
6. Accidents.
7. Patents.
8. Payments.
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Detail.

10. Intent.
11. Supplementary Data.
12. Material and Workmanship.
13. Transportation.
14. Track Work.
15. Obstacles.
16. Traffic.
17. Completion.
18. Provided by Purchaser.
19. Tenders.

Interlocking Stations.

20. Building.

Interlocking Plant.

21. Machine.
22. Leadout.
23. Pipe Lines.
24. Pipe Carriers.
25. Compensation.
26. Horizontal Cranks.
27. Vertical Cranks.
28. Switch and Lock Movement.
29. Deflecting Bars.
30. Jaws and Lugs.
31. Offsets.
32. Locks.
33. Tie Plates.
34. Rail Braces.
35. Tie Straps.
36. Detector Bars.
37. Adjustments.
38. Signals—General.
39. Dwarf Signals.
40. High Signals.
41. Bridge Signals.
42. Wire Lines.
43. Wire.
44. Chain Wheels.
45. Wire Carriers.
46. Wire Eyes.
47. Split Links.
48. Chain.
49. Lamps.
50. Pins.
51. Bolts, Screws and Washers.
52. Shore Foundations.
53. Concrete Foundations.
54. Concrete.
55. Painting.
56. Boxing.

GENERAL.

1. Specifications.

ADHERENCE.—All the work herein outlined is to be done in strict accordance with the specifications, the accompanying plans and such instructions as may be given from time to time by the Purchaser.

SPIRIT.—The nature and spirit of these specifications are to provide for the work herein enumerated to be fully completed in every detail for the purpose designed; and it is hereby understood that the Contractor in accepting the contract agrees to furnish any and everything obviously necessary for such construction.

SPECIAL WORK.—The Purchaser will furnish a description and drawings of all special work.

COPIES.—Duplicate copies of these specifications will be furnished by the Purchaser with request for tender.

2. Drawings.

PRELIMINARY.—The Purchaser will furnish with each copy of the specifications, copies of all drawings in dictating the work to be performed.

The Contractor shall examine these drawings, call the Purchaser's attention to any apparent errors and ascertain the Purchaser's wishes regarding the same before submitting a tender.

FINAL.—After the contract has been awarded, the Contractor shall submit three (3) sets of the drawings showing the proposed arrangement or construction, which require the Purchaser's approval, one set of which will be approved and promptly returned. Should changes in these drawings be necessary to meet the requirements of the specifications, one set will be promptly returned with such changes indicated in writing, and the Contractor may proceed with the work when such corrections have been made.

The Contractor shall furnish four (4) sets of working drawings for the Purchaser's files and upon request two (2) additional sets for the file of each other interested company.

Suitable framed manipulation chart and track diagram shall be furnished in place by the ....

3. Supervision.

SUPERVISION.—All work shall be under the supervision of the Purchaser's accredited representative hereinafter referred to as the Supervisor.

FOREMAN.—The Foreman of installation, and his men, shall be satisfactory to the Supervisor.

INSTRUCTIONS.—The Foreman of installation shall receive and act upon all instructions given by the Supervisor in writing.

3. Supervision—Continued.

INSPECTION.—All material and workmanship will be inspected thoroughly and carefully, and the Contractor will be held at all times to the spirit of the specifications.

The Supervisor shall be given free access to all parts of the work during the process of construction.

*The Purchaser will make a final inspection and tests within three (3) days after the completion of the work. Any defects or omissions noted during this inspection shall be made good by the Contractor without extra charge before the work will be accepted.

DEFECTIVE WORK.—The Contractor, upon being so directed by the Purchaser, shall remove, rebuild, or make good, without charge, any defective work.

*ACCEPTANCE.—The Purchaser will issue written acceptance of the plant as soon as his inspection has shown that all work has been completed in conformity with plans and specifications.

4. Alterations.

SPECIFICATIONS.—The Purchaser reserves the right to make changes in plans and specifications. All such changes shall be handled in the same manner as the originals.

*Alterations involving a change in the plans which will increase or decrease the amount of material to be furnished, or work to be performed by the Contractor, shall be classed as extras, and such allowances shall be made as may be mutually agreed upon in writing.

5. Permits.

The Purchaser will obtain all necessary permits. Work requiring permits shall not be performed until same have been provided.

6. Accidents.

PRECAUTION.—The Contractor shall place sufficient and proper guards for the prevention of accidents and shall put up and maintain at night, suitable and sufficient lights, except as specified in Article 16.

RESPONSIBILITY.—The Contractor shall save the Purchaser harmless and relieve him from all responsibility for any damage, injury, or loss suffered by any person or persons in the employ of the Contractor while such person or persons are engaged in the construction of interlocking, unless such damage, injury, or loss is caused by the negligence of the Purchaser.

7. Patents.

*PATENT ROYALTIES.—The Contractor will pay all patent royalties on patented articles furnished by him, and will protect the Railroad Company from all patent-right claims.

8. Payments.

*First Payment.—The Purchaser will pay ...... per cent. of the contract price upon the receipt of the material at destination.

*Second Payment.—The remaining .... per cent. of the contract price will be paid within .... days after the acceptance of the plant.

*Extras.—Payments for extras will be made in the same manner as prescribed for in the contract price.

9. Contract.

As soon as possible after the award is made, the contract, in accordance with the accompanying form, will be presented in duplicate to the Contractor for his signature, after which both copies will be signed by the Purchaser and one of them will be returned to the said Contractor.

DETAIL.

10. Intent.

The intent of this specification is to clearly describe all of the material and labor required for and the results to be obtained by the complete installation of a mechanically operated interlocking plant at .... on the lines of the .... Railroad, as shown in the plans and supplementary data hereto attached.

Results. Note.—This space is provided for a complete general description of the plant and all its adjuncts, and of the operating results to be obtained therefrom.

11. Supplementary Data.

Practice.—The Contractor's recognized best practice shall govern except as herein otherwise provided. The plans, drawings, and detail specifications attached to and forming a part of this specification are:

....

....

....

12. Material and Workmanship.

When it is necessary or desirable to use apparatus not heretofore in use, the Contractor shall submit drawings of the same with his proposal, and the acceptance of such proposal shall constitute acceptance of such new devices.

All material and workmanship shall be first-class in every respect.

12. Material and Workmanship.

*The Contractor shall furnish for replacement free on board at works any apparatus or material of his own manufacture or furnished on his own specifications, which shall prove defective after having been in service one year or less, provided it was used for its intended purpose.

The Contractor's standard apparatus shall be used, except as herein otherwise specified.

13. Transportation.

The Purchaser will .... furnish transportation for the men engaged in, and necessary tools and material required for, the installation of the plant over the following railway lines:

....
....
....
....

Shipment and Handling.—Tools and material are to be shipped
To ....
Care of ....
At ....
Via ....
Marked ....
Freight prepaid to...

The Purchaser will unload and properly house only such material as arrives before the Contractor's men.

The use of the following cars will be permitted under the restrictions and conditions of Articles Nos. 6 and 16, unless otherwise indicated in this paragraph:

	Number.	Furnished by.
Motor cars	....	....
Velocipede cars	....	....
Handcars	....	....
Pushcars	....	....

When Contractor is not permitted to use handcars or pushcars, the Purchaser will, at its own expense, distribute all material to the point of use upon receipt of notification from and under supervision of Contractor's Foreman.

When Contractor shall call upon the Purchaser for the required number of cars for the return of tools and unused material, and same will be furnished in .... days, after which time the Purchaser will, at his own expense, care for and load all tools and material.

14. Track Work.

The Purchaser will furnish:

All switches, derails and movable point frogs in place adjusted to the required throw.

All ties in place for the support of the apparatus.

All rail braces, and will install all except those located on tie plates furnished by the Contractor.

The Purchaser will move all ties which interfere with installation of the interlocking apparatus or connections.

The Purchaser will remove all guard rail clamps, rail braces, anticreepers and lips, and otherwise prepare the rail for the installation of detector bars.

14. Track Work—Continued.

The Purchaser will remove and replace all switch and tie rods (other than front rods on interlocked switches) requiring a change in location, the application of insulation, adjustment brackets or other alterations.

15. Obstacles.

The Purchaser will do all preliminary grading, provide adequate drainage, and blast and remove all solid rock that will interfere with the placing of the interlocking apparatus or connections.

*Where it is necessary to make an alteration or move any part of an existing structure, the same will be done by the Purchaser.

16. Traffic.

The Contractor shall not unnecessarily delay or interfere with traffic. When it becomes necessary for Contractor to perform any work which may endanger traffic, the Contractor shall notify the Purchaser and shall not proceed with said work until traffic is protected.

The Purchaser will promptly arrange to protect traffic upon request of Contractor.

17. Completion.

The Contractor shall notify the Purchaser, in writing, not less than seven (7) days before the plant will be ready for service.

The Contractor shall put the plant in service under the supervision of the Purchaser, and shall leave .... competent men on duty for .... hours thereafter.

The Purchaser will maintain and operate the plant as soon as it is put in service.

The Purchaser will put the plant in service, providing this cannot be done within three (3) days after the completion of the Contractor's work.

The Contractor shall remove and dispose of all excess earth and all refuse made by the Contractor's men or shall load on cars, where disposal cannot be made on right-of-way within interlocking limits.

18. Provided by Purchaser.

a ....
b ....
c ....
d ....
e ....

NOTE.—Items to be provided by Purchaser should be assembled and filled in at this point.

19. Tenders.

Sealed tenders for the work covered by these specifications will be received:

by ....

at ....

up to .... hour on the .... day of .... month .... of .... at which time and place said tenders will be opened. Bidders are invited to be present.

Tenders shall be divided as follows:

NOTE.—This space is provided for a complete description of the division of the tenders for the different portions of the work.

a ....

b ....

c ....

d ....

The Purchaser reserves the right to reject any and all bids.

20. Interlocking Stations.

A .... building .... stories high and .... x .... inside dimensions, with a .... frame for supporting the machine, shall be built by the .... in accordance with specifications and drawings No. .... for building and drawings No. .... for frame.

A .... foundation for the building and leadout supports shall be built by the .... in accordance with specifications and drawings No. .... Leadout supports shall be furnished in place by the .... in accordance with drawings No. ....

21. Machine.

(a) It shall be of the preliminary latch-locking type; levers shall be numbered from left to right, like parts of machine of same type shall be interchangeable, and all bolts shall be provided with jamb or lock nuts.

(b) All levers shall be arranged so that they can be removed without interfering with other levers.

(c) Levers shall be .... ft. .... in. in length from end of lever handle to center pin, and center pins shall be one and one-quarter (1¼) in. in diameter.

(d) All levers shall have equal and uniform throw, and shall be so arranged that connections may be made to front or back of lever. Tail levers for pipe connections shall be drilled to provide for eight and three-quarter (8¾) in., nine and three-quarter (9¾) in., and ten and three-quarter (10¾) in. stroke. Tail levers for wire connections shall be drilled for eight and three-quarter (8¾) in., ten and three-quarter (10¾) in., twelve and three-quarter (12¾) in., fourteen and three-quarter (14¾) in., and sixteen and three-quarter (16¾) in. stroke.

21. Machine—Continued.

(e) One lever shall operate not more than one signal, two pairs of switch points, one hundred and six (106) ft. of detector bars at single switches, or one hundred and fifty-six (156) ft. at slip switches, four rail locks, one switch and lock movement, two bridge locks, or two eight (8) way bridge couplers.

(f) Provision shall be made for one tappet or cross-locking bar, one lever shoe pin and caps, and one locking bar extending full length of the machine for each lever or space.

(g) The locking shall be distributed as uniformly as possible in the locking bed.

(h) Locking shafts on S. & F. type shall extend .... in. out from back rails and shall be drilled .... in. from end for applying electric locks, holes shall be .... in. in diameter and horizontal with levers on center.

(i) The front, back and intermediate rails supporting locking bed of S. & F. type shall be provided with one way caps.

22. Leadout.

(a) Rocking shaft, deflecting bar, or a combination of deflecting bar and vertical crank leadout, shall be furnished.

(b) Rocking shafts shall be made from two (2) in. square, rolled steel with movable bearings and movable crank arms. Straight and bent shaft arms shall be .... iron, eleven and three-quarters (11¾) in. long, center to center. Rocking shaft bearings shall be so arranged that both ends of all rocking shafts shall be supported, and no more than six (6) ft. of rocker shaft shall be unsupported.

(c) Rocker shaft stands shall be made of cast iron, center of bearing to the base of stand shall be fifteen (15) in., bases of stands shall be symmetrical and shall be cored for four (4) three-quarter (¾) in. bolts spaced .... x .... in. centers. Bearings shall be provided with one (1) way caps and shall be attached to stands with two (2) five-eighth (⅝) in. bolts.

(d) Vertical leadout chain wheels shall be made of malleable iron and shall be ten (10) in. in diameter. Stands for vertical chain wheels shall be drilled for bearings ten (10) in. and twelve (12) in. above base of bearing; bases shall be cored for two (2) three-quarter (¾) in. bolts .... in. centers.

(e) All leadout appliances shall be securely fastened to leadout supports by three-quarter (¾) in. bolts, bolt heads shall be placed underneath.

(f) All down rods shall be vertical with offset jaws, so that they may be connected to lever for either eight and three-quarter (8¾) in. or nine and three-quarter (9¾) in. stroke, and shall be connected to the eight and three-quarter (8¾) in. stroke hole.

22. Leadout—Continued.

(g) Shackles shall be connected to tail levers with standard seven-eighth (⅞) in. by two and one-quarter (2¼) in. pins for all wire lines, and sufficient movement of wire line shall be provided to successfully operate all wire connected signals.

23. Pipe Line.

(a) One inch pipe shall be used for connections to switches, derails, movable wing and point frogs, detector bars, locks, bridge couplers, and high home and .... signals.

(b) Pipe lines shall be straight where possible and shall not be placed less than four ft. six in. (4′-6″) from gage line, except where the line runs between tracks or permission is granted by the Purchaser. On draw spans and approaches, they shall be kept as far from gage line as conditions will permit.

(c) Where possible pipes in main pipe line shall be run so that they will lead off on track side in regular order.

(d) Top of pipe carrier foundations in main pipe line shall be one (1) in. below base of rail where conditions will permit.

(e) All cranks, compensators, and deflecting bars in main pipe run shall be so located as to leave field side clear for wires, trunking and additions.

(f) Pipe lines shall be laid two and three-quarters (2¾) in. between centers and shall be supported on pipe carriers placed not more than seven (7) ft. centers. The distance from base on which pipe carriers are supported to the center of pipe line shall be four and one-quarter (4¼) in.

(g) Couplings in pipe lines shall be located not less than twelve (12) in. from pipe carriers with lever on center.

(h) Where so specified on plans at points where pipe lines cross under tracks, roads, platforms, etc., standard one (1)-in. pipe shall be run inside of standard two (2) in. galvanized iron pipe, provided at each end with a stuffing box, which shall be provided with an oil inlet, and shall be attached to the pipe by standard pipe coupling. Design shall be such as to permit of standard spacing of pipe lines two and three-quarters (2¾) in. between centers.

(i) Where so specified I-beam track supports shall be used where pipe lines cross under tracks, and I-beam construction shall be built as per plan No. .... attached, and shall be furnished and put in place by the Purchaser.

(j) Except where otherwise provided, pipe lines run across tracks shall be arranged to permit standard spacing and proper tamping of ties.

(k) Pipes leading across tracks shall be supported by transverse pipe carriers fastened to top of ties where practicable.

(l) Turns in pipe lines shall be made with radial arms, cranks, or deflecting bars as follows:

23. Pipe Lines—Continued.

(m) *Angle of Deflection:*

0 degrees to 11 degrees
11 degrees to 33½ degrees
33½ degrees to 56 degrees
56 degrees to 78½ degrees
78½ degrees to 90 degrees

0 degrees to 30 degrees
30 degrees to 75 degrees
75 degrees to 105 degrees
105 degrees to 140 degrees
140 degrees to 180 degrees

Deflecting bars with tang ends:

22½ degrees deflecting bars with eye ends.
45 degrees deflecting bars with eye ends.
67½ degrees deflecting bars with eye ends.
90 degrees deflecting bars with eye ends.
15 degrees radial arm cranks.
60 degrees acute angle cranks.
90 degrees standard cranks.
120 degrees obtuse angle cranks.
180 degrees equalizing arms.

(n) Pipe lines shall be installed in accordance with temperature diagram, and table of equivalent lengths used in compensating pipe lines when crank arms are of unequal length.

(o) Deflecting bars, radial cranks, pipe, stuffing boxes, tang ends, plugs, and couplings shall be Railway Signal Association Standard.

24. Pipe Carriers.

(a) Pipe carriers for main pipe runs shall be of the anti-friction type, and constructed of individual sides, top and bottom rollers; sides shall be connected together at top; and in contact, but not connected at bottom; bases shall be cored for two (2) one-half (½) in. lag screws .... in. centers, and fastened to foundations with two (2) .... x .... in. lag screws.

(b) Transverse carriers shall be constructed of individual sides, top and bottom rollers, sides shall be supported by a wrought or malleable iron bearer, and connected together by a one-half (½) in. pin through center of bottom roller, connected to bearer, with one-half (½) in bolts, and fastened to foundations with two (2) three-quarter (¾) by four (4) in. lag screws.

(c) The pipe carrier shall be constructed of malleable or wrought iron frame and bottom roller, assembled together by one-half (½) in. pin through center of roller, and fastened to foundation with two (2) one-half (½) in. by two and one-half (2½) in. lag screws.

(d) All pipe carrier sides and bottom rollers shall be made of malleable iron.

25. Compensation.

(a) Compensation shall be provided for all pipe connected units or apparatus where same is necessary to insure proper operation.

(b) Unless compensation is otherwise provided for, a lazy jack compensator shall be provided for each pipe line over fifty (50) ft. in length and under eight hundred (800) ft., with crank arms ten by thirteen (10x13) in. centers. From eight hundred (800) to twelve hundred (1,200) ft. in length, crank arms shall be ten by sixteen (10x16) in. centers. Pipe lines over twelve hundred (1,200) ft. in length shall be provided with additional compensators. No more than seven hundred and twenty-five (725) ft. of pipe shall be compensated by an eleven and three-quarter (11¾) by eleven and three-quarter (11¾) in. crank.

(c) No more than one horizontal compensator or two vertical compensators shall be mounted in one stand.

(d) Compensators shall have one (1) sixty (60) degree and one (1) one hundred and twenty (120) degrees angle cranks, with bosses two (2) in. thick, and eleven (11) in. connecting link, mounted in cast iron bases, having top of center pin supported. The distance between center of pin holes shall be twenty-two (22) in., and bases shall be cored for four (4) three-quarter (¾) in. bolts spaced .... x .... in. centers.

26. Horizontal Cranks.

Cranks shall be made of wrought iron and drilled eleven and three-quarters by eleven and three-quarters (11¾x11¾) in. center to center, with boss two (2) in. thick. They shall be mounted in cast iron bases, having top of center pin supported. Not more than two (2) cranks shall be mounted in the same base, and no more than one crank mounted on one center. Bases shall be cored for four (4) three-quarter (¾) in. bolts, spaced .... x .... in. centers.

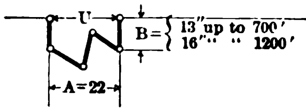
27. Vertical Cranks.

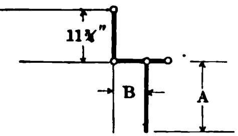
Cranks shall be made of wrought iron and drilled eleven and three-quarters by eleven and three-quarters (11¾x11¾) in. center to center, with boss two (2) in. thick. They shall be mounted in one and two way cast iron stands and drilled for bearings .... in centers above base, and base cored for four (4) three-quarter (¾) in. bolts, spaced .... x .... in. centers.

28. Switch and Lock Movement.

Switch and lock movement shall be securely bolted to five-eighth by twelve by .... ft. (⅝"x12"x............') iron plates, and shall be placed on outside of track .... ft. .... in. from gage of nearest rail bolted to ties.

COMMITTEE ON MECHANICAL INTERLOCKING COMPENSATION.





Values of "U" are based on .08 of an inch as coefficient of expansion for an increase of 10° F. for each 100' of line, and the nearest 1/16" is given.

Values of spacing "U" for given temperature and length of lines to be compensated and table of equivalent lengths to be used in compensating pipe lines when crank arms are of unequal lengths.

Temp. F°.	LENGTH OF LINES COMPENSATED IN FEET.											
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200
110°	21½"	21"	20½"	20"	19½"	19"	18½"	18"	17½"	17"	16½"	16"
90°	21 11/16"	21⅜"	21"	20 11/16"	20⅜"	20"	19 11/16"	19⅜"	19"	18 11/16"	18⅜"	18¼"
70°	21 13/16"	21 11/16"	21 9/16"	21⅜"	21 3/16"	21"	20⅞"	20 11/16"	20½"	20⅜"	20¼"	20⅛"
50°	MEAN TEMPERATURE U=A=22"											
30°	22 3/16"	22 5/16"	22½"	22⅝"	22 13/16"	23"	23 3/16"	23 5/16"	23½"	23⅝"	23¾"	23 15/16"
10°	22 5/16"	22⅝"	23"	23 5/16"	23⅝"	23 15/16"	24¼"	24 9/16"	24⅞"	25 3/16"	25½"	25⅞"
0°	22 7/16"	22 13/16"	23¼"	23⅝"	24 1/16"	24 7/16"	24 13/16"	25¼"	25 11/16"	26⅛"	26½"	26 13/16"
—10°	22½"	23"	23½"	24"	24½"	25"	25½"	26"	26½"	27"	27½"	28"

"A" Length in Feet.	EQUIVALENT FOR "A" FOR VARIOUS LENGTHS OF "B."											
	B-7"	B-7½"	B-8"	B-8½"	B-9"	B-9½"	B-10"					
25	42	39	37	35	33	31	29	......	......	......	......	......
50	84	78	73	69	65	62	59	......	......	......	......	......
75	126	117	110	104	98	93	88	......	......	......	......	......
100	168	157	147	138	130	124	117	......	......	......	......	......
150	252	235	220	207	196	185	176	......	......	......	......	......
200	336	313	294	276	261	247	235	......	......	......	......	......
250	419	391	367	345	326	309	294	......	......	......	......	......
300	503	470	441	415	391	371	352	......	......	......	......	......
350	587	548	514	484	457	433	411	......	......	......	......	......

Note.—Since the mean temperature varies, it must be taken for the latitude where the work is done.

29. Deflecting Bars.

(a) Deflecting bars shall be made in one way multiple unit type; bars shall be made of one and one-quarter (1¼) in. square steel, and designed for ten (10) in. stroke, and shall be bent at the following radii:

22½ degree, radius seventy-two (72) in.
45 degree, radius thirty-six (36) in.
67½ degree, radius twenty-four (24) in.
90 degree, radius eighteen (18) in.

(b) All cranks, compensators, deflecting bars, switch and lock movement, and stands shall be Railway Signal Association Standard.

30. Jaws and Lugs.

(a) Except where otherwise specified, solid jaws shall be used for connections to all cranks, compensators, deflecting bars, couplers, rail locks, pipe connected levers, and balance levers.

(b) The body of all jaws shall be of wrought iron, one and eleven thirty-second (1 11/32) in. in diameter, with tang and thread for coupling to pipe.

(c) The sides of solid jaws shall be parallel for three (3) in. from center of pin hole, and length of solid jaws shall be nineteen and one-half (19½) in. from center of pin hole to center of first rivet hole.

(d) Screw jaws shall be used as follows: one for each switch connection to bolt, front rod, lock rod, switch and lock movement, detector bar connection, in signal line on each side of bolt lock, and in each high signal down rod, and shall be located as close as possible to the unit to be adjusted.

(e) Screw jaws shall be made of .... iron, with hexagon shank ends the same size as the outside dimension of the one and one-quarter (1¼) in. standard jamb nuts.

(f) The sides of screw jaws shall be parallel for five (5) in. from center of pin holes, and length of screw jaw shall be nineteen and one-half (19½) in. from center of pin hole to center of first rivet hole with shank of jaw on center of thread.

(g) Each screw jaw shall be provided with jamb nut.

(h) Pipe lugs shall be made of wrought iron one and eleven thirty-seconds (1 11/32) in. in diameter, fitted with thread and tangs for coupling to pipe, and minimum distance from center pin hole to center of first rivet hole shall be .... in.

(i) All jaws, lugs and tangs shall be Railway Signal Association Standard.

31. Offsets.

Offsets in pipe lines shall be made in body of jaws, or in iron rod one and eleven thirty-seconds (1 11/32) in. in diameter. The total offset between any two supports shall never exceed three and one-half (3½) in., minimum distance between ends of offset shall never be less than twice the amount of the offset. Offsets in cranks and compensators shall be avoided as far as possible.

32. Locks.

(a) Facing point locks shall be used on all switches, derails, movable wing and point frogs, except where otherwise specified on plans. Locks shall be arranged to lock all switches in normal and reverse position, and all derails in reverse or closed position only.

(b) Facing point lock stands shall be placed on outside of track, twenty-eight (28) in. from gage and bolted to tie through a tie plate, placed on top of tie, and tie plate shall extend under and support the nearest rail and point. Facing point lock stands shall be arranged to support the plunger on each side of lock rod to support the lock rod on each side of the plunger, and bases shall be cored for four (4) three-quarter (3/4) in. bolts........x........in. centers.

(c) Facing point lock plungers shall be one (1) in. in least dimension, with square end and nineteen (19) in. in length from center of pin hole to end, have full stroke of pipe line, and stand one (1) in. clear of lock bar when switch is unlocked.

(d) Lock rods shall run direct from front rods into lock stands, and shall be of the double adjustable type. Holes or notches in lock rods shall have square edges and shall not be more than one-sixteenth (1/16) in. larger than plunger.

(e) When electric locking or switch circuit controllers are not used, all facing point switches, movable wing and point frogs on high speed routes shall be bolt locked with signals governing such routes; and all facing derails shall be bolt locked with all signals governing over them.

(f) All bolt lock stands shall be made in one (1) way multiple unit type, and cored for four (4) three-quarter (3/4) in. bolts.

(g) Switch bar in bolt lock shall be made of mild steel .... x .... with .... in. notch, and have an independent connection to switch point and shall not be connected to front, lock, throw rods, or point lugs, if front rod is attached to them.

(h) Signal bar in bolt lock shall be made of mild steel .... x .... with .... in. notch, and be a part of the pipe line, and not lugged or looped in.

(i) Lock stands, plungers, front rods, lock rods, and switch lugs shall be Railway Signal Association Standard.

NOTE.—Where local conditions are such that it is not practicable to install bolt locking the Committee recommends circuit controllers on switches, derails, movable wing and point frogs, and their respective operating levers with electric locks on lock levers to insure that switches have responded to the position of the lever, or where slotted signals are used, they shall be controlled by circuit controllers on switches, derails, movable wing and point frogs.

33. Tie Plates.

(a) Three tie plates shall be used for all switches and derails, and shall be located as follows: one on point tie, and one on nearest tie on either side. Four tie plates shall be used for each set of movable point frogs, and shall be located as follows: one on point tie, and one on first tie back of the point tie for each pair of points.

(b) Tie plates shall be one-half in. by six in. by .... (½"x6"x...........); butt plates shall be .... x .... x .... and drilled for .... in. rivets. Riser plates shall be .... x .... x .... and drilled for .... in. rivets. All tie plates shall be fitted in place and securely fastened to the ties with .... three-quarter by four (¾x4) in. lag screws.

34. Rail Braces.

Rail braces shall be furnished by the Purchaser.

35. Tie Straps.

(a) At all switches, derails, movable wing and point frogs, tie straps shall be used, to tie all crank, rocker shaft, point and intermediate ties together.

(b) Tie straps shall be one-half by two and one-half (½x2½) in. iron, placed on top of ties and fastened to the ties with three-quarter by four (¾x4) in. lag screws.

36. Detector Bars.

(a) Bars shall be located as shown on .... Plan No. .... date .... attached hereto, unless otherwise specified.

(b) Bars on curves shall be located on inside, outside or both sides of curve as determined by local operating traffic conditions.

(c) Detector bars shall be arranged to give fifty-three (53) ft. continuous protection for all switches, derails, movable wing and point frogs, and shall lap the switch points a distance equal to the stroke of the bar.

(d) Detector bars shall be three-eighth by two and one-quarter (⅜x 2¼) in. steel, have one bevelled edge, square ends, and bolted joints, and shall be made up in eighteen ft. sections.

(e) Bars shall be drilled one (1) in. from bottom of bar to center of hole for three (3) one-half (½) in. countersunk head bolts or rivets. The first hole shall be one (1) in. from end to center and two (2) in. between centers of holes. Splice plates shall .... be used; they shall be of wrought iron one-half by two by twelve (½x2x12) in., riveted at one end of bar with three (3) one-half by one (½x1) in. countersunk head rivets and attached to intermediate sections by three (3) one-half by one and one-quarter (½x1¼) in. countersunk head bolts, with nuts held in place by nutlocks.

(f) Driving pieces shall be made of wrought iron arranged for one and eleven thirty-second (1 11/32) in. jaw connections. The part where the jaw is connected shall be three-quarters by two by three

36. Detector Bars—Continued.

(¾x2x3) in.; and part riveted to bar shall be one-half by two by six (½x2x6) in., drilled for three (3) one-half (½) in. rivets; one (1) in. from end and two (2) in. between center of holes. Offset from bar to jaw connection shall be one and one-half (1½) in.

(g) Driving pieces shall be placed midway between two (2) clips in space not equipped by joint, and the driving rod shall have not more than seven (7) ft. unsupported.

(h) Fifty-three (53) ft. bars shall be mounted on sixteen (16) .... type rail clips, and a proportionate number of clips shall be used for longer or shorter bars.

(i) Centers of rail clips shall be placed eight (8) in. and twenty-six (26) in. respectively from each end, and the remaining clips approximately four (4) ft. apart.

(j) Where radial arm clips are used combination bar stops and guides shall be provided for each ten (10) ft. of bar (equally spaced), and not less than two (2) such stops on one bar.

(k) Bars shall be mounted substantially and operated close to head of rail in a plane inclined toward the center of track.

(l) Bars shall rise a minimum of three-quarters (¾) in. above top of rail during the locking and unlocking of the switch and shall rest one-quarter (¼) in. below top of rail when lever movement is completed.

(m) Where rocking shafts are used, they shall be made of two (2) in. rolled steel with movable bearings and crank arms. Arms shall be............iron and nine (9) inches center to center. The bearings shall be securely bolted to ties with four (4) three-quarter (¾) in. bolts. The maximum spacing of supports shall be six (6) ft. centers.

(n) Detector bar fittings shall be Railway Signal Association Standard.

37. Adjustments.

(a) Open turnbuckles shall be placed in each pipe line as follows: One for each facing point lock, switch and lock movement, pipe connected high home, dwarf, or pot signal; bridge lock and couplers, located as near to the last operated unit as it is possible to get them, without having them directly under the rails, guardrails, frogs, switches or bridge guards.

(b) Open turnbuckles shall be made of............iron, with right and left hand thread, capable of giving an adjustment of not less than six (6) in., and provided with hexagon end shanks, which shall be the same size as the outside diameter of the one and one-quarter (1¼) in. standard jam nut. Threaded rods shall be made of one and eleven-thirty-second (1$\frac{11}{32}$) in. wrought iron, provided with standard tang ends, threads and couplings.

(c) Wire lines for wire connected distant signals shall be provided with two (2) adjusting screws for each wire, one in the tower, and one at base of signal pole.

37. Adjustments—Continued.

(d) Wire lines for wire connected dwarf signals shall be provided with one (1) adjusting screw for each wire and shall be placed in the tower.

(e) Wire adjusting screws shall be made of wrought iron not less than one-half (½) in. diameter with right and left hand thread, and shall be capable of giving an adjustment of twelve (12) in.

(f) Switches, derails, movable wing and point frogs shall be provided with special switch adjustment fastened to the head rod.

(g) Switches, movable wing and point frogs, and split point derails shall open not less than .... in.

38. Signals.

(a) General.—All signals shall be of the semaphore type with arm travel............degrees in the............right hand quadrant.

(b) Not more than one arm shall be placed on a dwarf signal post.

(c) Not more than three arms shall be placed on a high signal post, bridge, or bracket doll.

(a) Location.—The general type of signals are shown in the Railway Signal Association symbols and the location of signals shown shall be in accordance with scale plan No..........., dated............ revised..............

(b) All signal posts shall be on the right of the track governed, and adjacent thereto when possible.

(c) The arms shall be at right angles to the track governed on tangents, and at right angles to one thousand (1000) ft. chord on curves, or the total chord if curve is less than one thousand (1000) ft. long.

(d) Signals placed between tracks on tangents shall be set so that the center of post shall be midway between tracks. Signals placed between tracks on curves shall be set off the center line between tracks and towards the center of the curve two and one-half (2½) in. for each one (1) in. elevation in the outside of the curve.

(e) The balance levers on wire connected high signals located between tracks shall be set parallel to tracks.

(f) The Contractor shall notify Purchaser if tracks are less than .... ft. center to center for high signals, and .... ft. center to center for dwarf signals, which are shown between tracks or if any signals are shown within fouling limits.

(g) Outside of tracks, dwarf signal posts shall be placed .... ft. from nearest rail, high signal posts .... ft. and bracket posts .... ft.

(h) Base of dwarf signals shall be two (2) in. below base of rail. Base of high signals shall be .... in. below base of rail.

39. Dwarf Signals.

(a) Dwarf signals shall be .... position of the .... type.

(b) Posts shall be made of wrought iron pipe .... in. in diameter .... ft. .... in. from base to center of bearing, and .... ft. .... in. from base to center of arms. Arms shall be flexible or hinged, of ....,........ in. x ....in. x .... in., placed so that outer end is ....in. from vertical line through center of shaft. Arms shall be fastened to arm casting by two (2) bolts .... x ...., ... in. center to center vertically.

(c) Arm casting shall be made of .... iron, capable of holding one (1) .... glass, one (1) .... glass, and one (1) .... glass, solid color. Each glass shall be .... in. in diameter x .... in. thick with centers .... in. from center of shaft. Back lights will .... be required.

(d) Back light castings shall be capable of holding one (1) .... glass, solid color. Glass shall be .... in. in diameter x .... in. thick.

(e) Semaphore shaft shall be made of cold rolled steel .... in. square.

(f) Base castings for dwarf signals shall be cored for .... bolts .... in. in diameter at a radius of .... in.

40. High Signals.

(a) High speed signals shall be .... position.

(b) Medium speed signals shall be .... position. Low speed signals shall be .... position.

(c) Straight pipe posts shall be made of six (6) in., five (5) in., and four (4) in. wrought iron pipe with water-tight joints, and the size, weight, and length of the wrought iron pipe shall be

Item.	Size.	Weight per ft.	Length.
Top section	4 in.	10.66	10 ft.
Second section	5 in.	14.56	10 ft.
Third section	6 in.	18.76	To meet specification as to length.

(d) The length of straight post shall be as follows:
One arm 24 ft. 6 in.
Two arm 31 ft.
Three arm 37 ft. 6 in.

(e) The spacing of arms shall be as follows: distance from top shaft to second shaft six (6) feet six (6) inches, and from second shaft to third shaft ten (10) feet.

(f) Posts shall be mounted in base castings. Base castings shall be cored for four (4) one (1) in. bolts at a radius of .... in.

40. High Signals—Continued.

(g) Center of arms shall be .... in. .... the center of shaft. Arms shall be made of ...., ... in. x .... in. from vertical line through center of shaft, and shall be fastened by .... bolts .... in. x .... in. spaced .... in. center to center vertically and .... in. center to center horizontally.

(h) Arm castings shall be made of ...., capable of holding one .... glass, one .... glass, and one .... glass, solid color. Each glass shall be .... in. in diameter x .... in. thick, with centers .... in. from center of shaft. Back lights will .... be required.

(i) Back light castings shall be capable of holding one .... glass, solid color. Glass shall be .... in. in diameter x .... in. thick.

41. Bridge and Bracket Signals.

(a) All bridge and bracket dolls shall be made of four (4) in. pipe, mounted in .... base castings. Base castings shall be cored for four (4) bolts one (1) in. in diameter at a radius of .... in.

(b) Top of cross-trees shall be .... ft. .... in. above base of bracket post.

(c) Bracket post shall be made of nine (9) in. and eight (8) in. wrought iron pipe with water-tight joints mounted in .... base castings. Base casting shall be cored for four (4) bolts one and one-half (1½) in. diameter at a radius of .... in.

(d) Bridge dolls shall be located on .... chord of bridge.

(e) All signals, fittings, and glass shall be Railway Signal Association Standard.

42. Wire Lines.

(a) Two wires shall be used for operating each wire connected signal; the normal operating wire shall have two (2) in. more stroke than the reverse operating wire.

(b) Wire lines shall be carried in wire carriers placed not more than twenty-one (21) ft. apart. Where wire lines run next to pipe lines, the wire carriers shall be attached to the pipe carrier foundations.

(c) Where wire carriers are attached to independent foundations, they shall be placed not less than six (6) ft. from gage of nearest rail where practicable.

(d) Where wire lines lead around curves the carriers shall be placed at the proper angle to prevent wire leaving groove of pulley.

(e) Turns in wire lines shall be made around chain wheels with a continuous piece of chain not less than four (4) ft. in length.

(f) Where specified on plans, wires shall be run inside of three-eight (⅜) in. galvanized iron pipe under tracks, roads, platforms, etc., provided at each end with a stuffing box attached to the pipe; stuffing boxes shall be provided with oil inlet.

43. Wire.

Signal wire shall be hard drawn, galvanized steel No. 8 B. W. G. (.165 in. in diameter). The wire shall be cylindrical, free from scales, inequalities, splices, and other defects. Each coil shall consist of one continuous wire not less than two thousand (2000) ft. in length and five feet in diameter. A single strand of this wire shall be capable of standing a load of two thousand (2000) lbs., and the elongation shall not exceed four (4) per cent. in a length of six (6) in. A specimen taken from a coil must be capable of standing four (4) close turns around its own diameter.

44. Chain Wheels.

(a) Chain wheels shall be made of malleable iron. Not more than two (2) shall be mounted in vertical line. The diameter of wheels shall be ten (10) in., except box wheels and wheels used in dwarf signal lines, which may have a minimum diameter of six (6) in.

(b) Stands for chain wheels shall have top, bottom, and intermediate supports. Distance between supports shall be .... in. and bottom of bottom support shall be .... in. above base. Wheels to be assembled with .... x .... in. steel pins. Bases shall be cored for four (4) three-quarter (¾) in. bolts .... x .... in. centers.

45. Wire Carriers.

Sheaves for wire carriers shall be two (2) in. in diameter over all and shall be made up in two (2), four (4) and six (6) ways, with no more than two (2) sheaves in vertical line. Stands shall be drilled for bearings .... in., and .... in. above base of bearing. Bearing of sheaves shall be supported by .... sheaves, and stands shall be made of malleable iron, and shall be secured to foundation with two (2) one and one-half (1½) in. number fourteen (14) screw.

46. Wire Eyes.

Standard one and one-half (1½) in. galvanized wire eyes shall be used in making all wire connections.

47. Split Links.

Split links shall have three-quarter (¾) by one and five-eighth (1⅝) in. inside dimensions and be made of five-sixteenth (5/16) in. galvanized steel. After connections are made points shall be closed.

48. Chain.

(a) All signal chain shall be made of one-quarter (¼) in. diameter .... iron, and shall have a maximum of fourteen (14) links to the foot. The inside dimensions of the links shall be thirteen-sixteenths by one and three-eighths (13/16x1⅜) in.

48. Chain—Continued.

(b) All signal chain shall withstand a breaking test of three thousand (3000) lbs., and the elongation shall not exceed ten (10) per cent. Test to be made with piece of chain twelve (12) in. long, which shall show no deformation after test. Any link showing imperfection under proof test of twelve hundred (1200) lbs. shall be replaced before the chain will be accepted.

49. Lamps.

Lamps shall be Railway Signal Association Standard and shall be furnished by ....

50. Pins.

(a) All pins shall be made of steel with a permissible variance of .002 in. under size.

(b) Center pins for cranks, compensators, and switch and lock movements shall be interchangeable, and shall be one and one-quarter (1¼) in. by .... in., flattened at lower end to enter an oblong hole in the stands to prevent turning, with a groove in upper end so that they can be easily removed, and cotter pin holes shall be large enough to prevent shearing strain on one-quarter (¼) in. cotter.

(c) Connecting pins for cranks, compensators, machine tail levers, bolt locks, switches, pipe connected levers, etc., shall be seven-eighths by two and three-eighths (⅞x2⅜) in. under head drilled for three-sixteenth ($\frac{3}{16}$) in. cotter and two and one-eighth (2⅛) in. from under side of head, and heads of all connecting pins shall be either square or hexagon.

51. Bolts, Screws and Washers.

(a) All bolts, tap bolts, set screws and machine screws shall have United States standard screw threads, nuts and heads.

(b) All nuts, bolt heads, tap bolts and set screws in connection with the machine shall have hexagon heads, and all other nuts, bolt heads, tap bolts, set screws, etc., shall have square heads.

(c) All lag screws shall be standard with gimlet points and square heads. They shall be screwed their entire length in holes previously filled with oil, and holes shall be bored small enough to provide full thread.

(d) Flat cut washers shall be used under bolt heads, nuts and heads of lag screws where they come in contact with wood.

52. Shore Foundations.

(a) Pipe carrier foundations shall consist of cast iron piers, and wood or iron tops and bottoms as specified, or of concrete.

(b) Cast iron pipe carrier foundation piers shall be two (2) ft. five and one-half (5½) in. long, cored at top for two (2) one-half (½) in. bolts, spaced five and one-half (5½) in. between centers, cored at bottom for one (1) one-half (½) in. bolt one and one-quarter (1¼) in.

52. Shore Foundations—Continued.

from center line, and the average weight of piers shall be not less than twenty-two (22) lbs.

(c) Wood pipe carrier foundation tops and bottoms shall be made of two and three-quarter by seven and three-quarter (2¾x7¾) in. yellow pine lumber, dressed four (4) sides.

(d) Foundation for one (1) one (1) way pipe carrier in main pipe line shall be seventeen and one-half (17½) in. long and two and three-quarters (2¾) in. shall be added for each additional pipe carrier.

(e) Foundations used for one way pipe carriers in transverse pipe lines shall be twelve (12) in. long.

(f) Pipe carrier foundation tops shall be bored at each end for two (2) one-half (½) in. bolts one and one-half (1½) in. from end to center and five and one-half (5½) in. between centers. Pipe carrier foundation bottoms shall be bored at each end for one (1) one-half (½) in. bolt three (3) in. from end and one and one-quarter (1¼) in. from center line.

(g) Two (2) cast iron piers shall be used for each pipe carrier foundation up to forty-five (45) in. long, and one additional pier shall be provided for each additional thirty-six (36) in. or fraction thereof, and intermediate piers shall be inverted.

(h) Pipe carrier foundation tops and bottoms shall be fastened to piers with one-half by four (½x4) in. bolts.

53. Concrete Foundations.

(a) Cranks, compensators and bolt locks shall be fastened to iron piers arranged with slot for three-quarter (¾) in. bolts, and set in concrete. Plank to hold dwarf signals, deflecting bars, wheels, etc., shall be four by twelve (4x12) in. yellow pine, dressed two (2) sides, and fastened in a similar manner.

(b) All foundations shall be so constructed that apparatus can be removed without disturbing the foundations.

(c) Foundations for straight signal post shall consist of four (4) one (1) in. by three (3) ft. bolts set to templet in concrete.

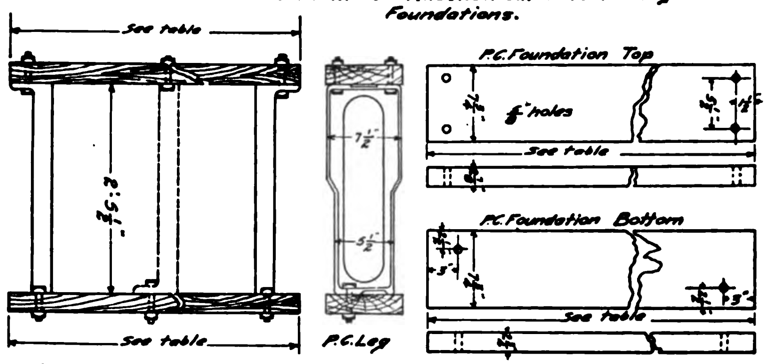
(d) Foundations for bracket signals shall consist of four (4) one and one-half in. by .... ft. (1½ in. x............ ft.) bolts set to templet in concrete.

(e) All concrete foundations shall be set parallel to track.

(f) Dimensions of concrete foundations shall be as follows:

	Top.	Base.	Depth.
Cranks	20x18 in.	36x34 in.	36 in.
Compensators	34x18 in.	50x34 in.	36 in.
Two way chain wheels	22x18 in.	38x34 in.	36 in.
Dwarf signal	30x16 in.	30x16 in.	36 in.
Straight post signal	26x26 in.	36x36 in.	4 ft.
Bracket signal	38x38 in.	48x48 in	5 ft.

Committee on Mechanical Interlocking Foundations.

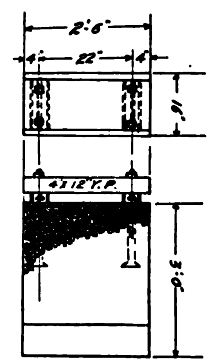


P.C. Foundation complete

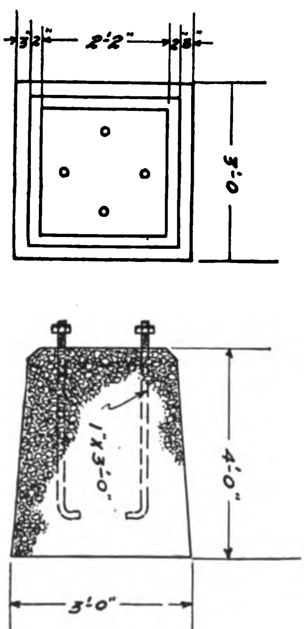
Table

No wanted	Ways	Space req'd. for P.C.	Length of tops & bottoms
	1	5 1/2"	17 1/2"
	2	8 1/4"	20 1/4"
	3	11"	23"
	4	13 3/4"	25 3/4"
	5	16 1/2"	28 1/2"
	6	19 1/4"	31 1/4"
	7	22"	34"
	8	24 3/4"	36 3/4"
	9	27 1/2"	39 1/2"
	10	30 1/4"	42 1/4"
	11	33"	45"
	12	35 3/4"	47 3/4"
	13	38 1/2"	50 1/2"
	14	41 1/4"	53 1/4"
	15	44"	56"
	16	46 3/4"	58 3/4"
	17	49 1/2"	61 1/2"
	18	52 1/4"	64 1/4"
	19	55"	67"
	20	57 3/4"	69 3/4"
	21	60 1/4"	82 1/4"
	22	63"	85"
	23	65 3/4"	87 3/4"
	24	68 1/2"	90 1/2"

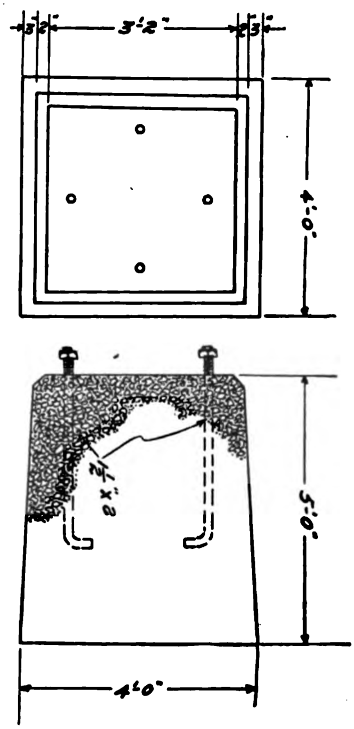
One way cross lead pipe carriers 12"



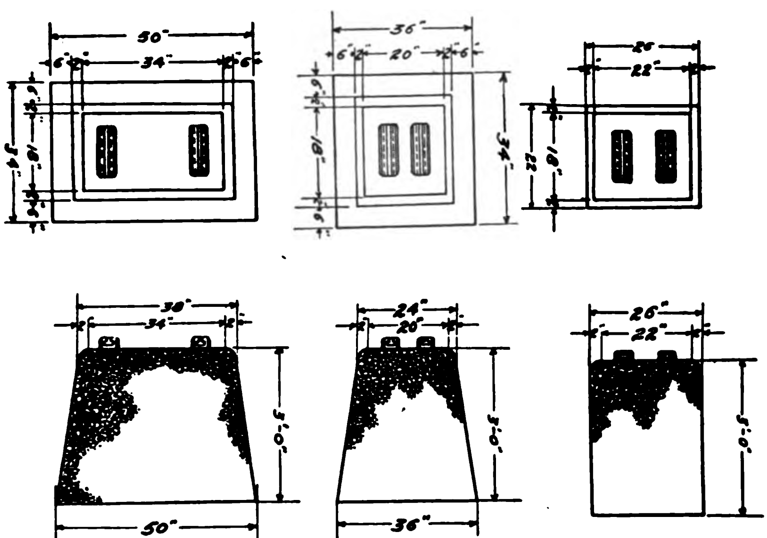
Dwarf signal foundation.



Straight signal pole foundation.



Bracket signal foundation.



Compensator foundation. Crank foundation. 2 way wheel foundation.

NOTE.—Contractor is requested to use his best judgment as to proper size and depth of base; to be governed by nature of ground. These styles are adaptable to good solid ground.

53. Concrete Foundations—Continued.

(g) Concrete foundations shall stand until properly set before any apparatus is connected thereto.

(h) All foundations shall be rigid, level, and in perfect line.

(i) Wooden stakes for wire lines shall be three by four inches by five feet (3 in. by 4 in. x 5 ft.) with seven (7) in. point.

NOTE.—The plans and specifications for concrete foundations are adaptable to solid grounds. The Contractor is expected to use his best judgment as to the proper size and depth; and he will be governed by nature of ground.

54. Concrete.

(a) Concrete shall be made of one part Portland cement, three parts sand, six parts of broken stone and water to make proper consistency.

(b) The outer exposed face to a thickness of one (1) in. shall consists of one part Portland cement, one and one-half (1½) part sand, deposited simultaneously with the interior mass. The top surface shall be floated and rubbed smooth by hand and true to grade and line.

55. Painting.

(a) GENERAL.—All material shall be pure and the quality of paint mixed shall be such as will permit of the application herein specified.

(b) CLEANING.—Surfaces covered with rust, grease, dirt, or other foreign substances shall be thoroughly cleaned before paint or oil is applied.

(c) APPLICATION.—General. Paint shall not be applied to outside surfaces in freezing weather or to wet surfaces until they are thoroughly dried.

(d) Pigment finishing coats shall be sufficient body to form an opaque coating.

(e) Finishing coats shall not be applied until after the expiration of forty-eight (48) hours after the previous coating has been applied.

(f) All priming coats shall be applied as soon as is consistent with the progress of the work.

(g) All second coats shall be applied in sufficient time for the third coat to be applied and dry when the plant is completed.

(h) All iron work, except machine, tie plates, and iron foundation piers, shall be painted one coat of red lead and raw linseed oil, and two (2) finishing coats.

(i) The following specific finishing coats shall be used:

	Kind of paint.	Color.
Signal bridges and brackets	....	....
Signal masts	....	....
All connections	....	....

55. Painting—Continued.

(j) MACHINE.—The machine shall be painted one priming coat and one finishing coat of black japan from top of latch shoes to foundation supports.

(k) The levers shall be painted one priming coat and two finishing coats, as follows:

Lock levers, blue.

Switch levers, black.

Switch and lock levers, black and blue. Bottom half black and top half blue.

Distant signal levers, lawn green or lemon-yellow.

Home signal levers, vermilion.

Spare levers, white.

(l) The unfinished part of latch handle shall be painted same color as lever.

(m) All painted parts of machine above the floor shall have one coat of outside finishing varnish. The finished parts of the machine shall not be painted. All machine finished metal shall be slushed in white lead and linseed oil, except locking, which shall be coated with vaseline before being shipped.

(n) All chain and other iron work, not machine finished, shall be dipped in oil before being shipped.

(o) WOOD WORK.—Exposd wood work shall be given one priming coat and finishing coats as follows:

	Kind paint.	Color.	Number coats.
Home signal blades	......	......	......
Dwarf signal blades	......	......	......
Distant signal blades	......	......	......
Foundation tops and bottoms	......	......	......

(o) BUILDING.—Signal stations, if built of wood, shall receive one priming coat and two finishing coats as specified below.

(q) The priming coat shall consist of yellow ochre, and, when thoroughly dry, two coats of pure lead and oil, in the following tints:

....

....

Prepared paints manufactured by..

....

....

will be accepted.

56. Boxing.

Where boxing is specified, it shall be made of two by eight (2x8) in. lumber, dressed on one side. If bottom in boxing is specified, it shall be made of one (1) in......... rough lumber. Where boxing is required through highways, the sides shall be made of three by six

56. Boxing—Continued.
(3x6) in. and three by ten (3x10) in. .... lumber and shall be spiked to the foundation tops. Four by twelve (4x12) in. .... lumber shall be used for the tops and it shall be cut diagonally, and not nailed to the sides.

These specifications for Mechanical Interlocking have been adopted by the Railway Signal Association, and it is therefore recommended that they be adopted by the Association and substituted for the Mechanical Interlocking Specifications now embodied in the Manual, although some slight amendments to these specifications will doubtless be necessary in the next two or three years. It will be noted that the Specifications for Mechanical and for Electric Interlockings follow substantially the same lines, and any differences will be reconciled by the Railway Signal Association during the coming year.

SUBJECT NO. 2. ELECTRIC INTERLOCKING SPECIFICATIONS.

Herewith follows the report of standing Committee No. III of the Railway Signal Association, on Standard Specifications for Electric Interlocking:

HISTORICAL.

Mr. W. McC. Grafton, in a paper read before the students of the University of Wisconsin, gives the dates of the first installations of power interlocking.

The first power plant built was a pneumatic machine which was erected and put into service in 1876 at the south end of the "Y" leading to the Centennial tracks at West Philadelphia. A hydraulic machine was first put into service at Wellington, Ohio, in 1880. A hydro-pneumatic machine was first put into service at Bound Brook, N. J., in 1884. An electric machine was first put into service at Cincinnati, Ohio, in 1890. The electro-pneumatic machine was first put into service at Jersey City, N. J., in 1891.

ANALYTICAL AND ARGUMENT.

It has been the endeavor of the Committee to submit specifications for a power plant for electric interlocking work in such a way as to fix the essential elements as well as to establish their proper capacity ratio. The instructions of the Association have been followed by including various notes of explanation as to methods by which the subject matter of certain clauses has been determined.

The question of signals as covered by Section 50 has been reconsidered and revised so as to include the work of Committee No. I.

The Association has given the Committee, under Section 60, the benefit of a great deal of discussion as to switch fitting, particularly as to the question of the lock rod. The Committee has felt that the financial side of any radical change in construction of lock rods which would make necessary a change in switch and lock movements should be handled with due deliberation. The Committee feels that there should at this time be given a full consideration of the substitution of some form of hard metals, with a proper adjustable feature, in the locking faces of plunger and rod rather than a radical change in structure. The subject, a vital one, can be viewed as of somewhat the same importance in its line as is that of the frog point in track work where hard metals are now being tested.

The specifications for wire trunking have been drawn with a view of reducing the number of sizes as used as well as securing uniformity in installation.

The drawbridge specifications in sections 130, 131 and 132 may conform to those of Committee No. II, except in the item peculiar to power interlocking as to the cutting off of the power from the control connections of the interlocking plant when the bridge lock lever is normal.

The Committee realizes the disadvantage to the members of the present lack of adopted specifications for electric interlocking by this Association. There has been no attempt by the Committee to introduce any radical change in the best present accepted practice of the members, but rather to submit an outline which can be adopted as a basis for future advance as experience dictates.

It has been the aim of the Committee to meet the wishes of all concerned by a full and free discussion of the points at issue so as to delay as little as possible the work of the Association in annual meeting.

The Committee would again call attention to invitations that have been issued to the signal companies to meet the Committee at all sessions.

STANDARD SPECIFICATIONS FOR ELECTRIC INTERLOCKING.

Definitions of Terms Used in the Specifications.

LANTERN.—A cage or body surrounding, protecting and equipped with a lamp or other source of illumination.

CONVERTIBLE LANTERN.—A lantern equipped for the use of either oil or electric lamps.

SIGNAL BRACKET.—A column or post with offset support (or supports) for signal masts.

SPECIFICATIONS.

General.

1. Specifications.
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3. Supervision.
4. Alterations.
5. Permits.
6. Accidents.
7. Payments.
8. Contract.

Detail.

10. Intent.
11. Supplementary Data.
12. Material and Workmanship.
13. Transportation.
14. Track Work.
15. Obstacles.
16. Traffic.
17. Completion.
18. Provided by Purchaser.
19. Tenders.

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20. Tower.
21. Power House.
22. Foundations.
23. Gasoline Tank.
24. Lighting.
25. Appurtenances.

Power Plant.

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31. Engine.
32. Generator.
33. Motor.
34. Motor Generator.
35. Transformers.
36. Storage Battery.
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Machine.

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41. Locking.
42. Levers.
43. Indication.
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GENERAL.

1. Specifications.

ADHERENCE.—All the work herein outlined is to be done in strict accordance with the specifications, the accompanying plans and such instructions as may be given from time to time by the Purchaser.

SPIRIT.—The nature and spirit of these specifications are to provide for the work herein enumerated to be fully completed in every detail for the purpose designed; and it is hereby understood that the Contractor in accepting the contract agrees to furnish any and everything obviously necessary for such construction.

SPECIAL WORK.—The Purchaser will furnish herewith description and drawings of all special work.

COPIES.—Duplicate copies of these specifications will be furnished by the Purchaser with request for tender.

2. Drawings.

PRELIMINARY.—The Purchaser will furnish with each copy of the specifications, copies of all drawings indicating the work to be performed.

The Contractor shall examine these drawings, call the Purchaser's attention to any apparent errors and ascertain the Purchaser's wishes regarding the same before submitting a tender.

FINAL.—After the contract has been awarded, the Contractor shall submit three (3) sets of the drawings showing proposed arrangement or construction, which require the Purchaser's approval, one set of which will be approved and promptly returned. Should changes in these drawings be necessary to meet the requirements of the specifications, one set will be promptly returned with such changes indicated in writing, and the Contractor may proceed with the work when such corrections have been made.

The Contractor shall furnish four (4) sets of working drawings for the Purchaser's files and upon request two (2) additional sets for the file of each other interested company.

Suitable framed manipulation chart and track diagram shall be furnished in place by the ....

3. Supervision.

SUPERVISION.—All work shall be under the supervision of the Purchaser's accredited representative hereinafter referred to as the Supervisor.

FOREMAN.—The Foreman of installation, and his men, shall be satisfactory to the Supervisor.

INSTRUCTIONS.—The Foreman of installation shall receive and act upon all instructions given by the Supervisor in writing, which do not involve additional expense to the Contractor.

INSPECTION.—All materials and workmanship will be inspected thoroughly and carefully, and the Contractor will be held at all times to the spirit of the specifications.

3. Supervision—Continued.

The Supervisor shall be given free access to all parts of the work during the process of construction.

The Purchaser will make a final inspection and tests within three (3) days after the completion of the work. Any defects or omissions noted during this inspection shall be made good by the Contractor without extra charge before the work will be accepted and paid for in full.

DEFECTIVE WORK.—The Contractor, upon being so directed by the Purchaser, shall remove, rebuild or make good, without charge, any defective work.

4. Alterations.

SPECIFICATIONS.—The Purchaser reserves the right to make changes in plans and specifications. All such changes shall be handled in the same manner as the originals.

EXTRAS.—Alterations involving an increase in cost of the amount of material to be furnished, or an increase in cost of work to be performed, shall be classed as extras.

CREDITS.—Alterations involving a decrease in cost of the amount of material to be furnished, or a decrease in cost of work to be performed, shall be classed as credits.

COMPENSATION.—No compensation shall be allowed for extras or credits unless agreed to in writing.

5. Permits.

The Purchaser will furnish all necessary permits. Work requiring permits shall not be performed until same have been provided.

6. Accidents.

PRECAUTION.—The Contractor shall place sufficient and proper guards for the prevention of accidents and shall put up and maintain at night, suitable and sufficient lights, except as specified in Article 16.

RESPONSIBILITY.—The Contractor shall save the Purchaser harmless and relieve him from all responsibility for any damage, injury or loss suffered by any person or persons in the employ of the Contractor while such person or persons are engaged in the construction of interlocking, unless such damage, injury or loss is caused by the negligence of the Purchaser.

7. Payments.

FIRST PAYMENT.—The Purchaser will pay .... per cent. of the contract price upon receipt of the material on the site of the work.

SECOND PAYMENT.—The plant will be accepted and remaining ....per cent. of the contract price will be paid within thirty (30) days after completion in conformity with the plans and specifications.

EXTRAS.—Payments of extras involving additional compensation will be made in the same manner as prescribed for the contract price.

Credits involving a reduction in compensation will be reduced from the contract price.

8. Contract.

As soon as possible after the award is made, the contract, in accordance with the accompanying form, will be presented in duplicate to the Contractor for his signature, after which both copies will be signed by the Purchaser and one of them will be returned to the said Contractor.

DETAIL.

10. Intent.

The intent of this specification is to clearly describe all of the material and labor required for and the results to be obtained by the complete installation of an electrically operated interlocking plant at .... on the lines of the .... R. R., as shown in the plans and supplementary data hereto attached.

RESULTS.—Note.—This space is provided for a complete general description of the plant and all its adjuncts and of the operating results to be obtained therefrom.

11. Supplementary Data.

PRACTICE.—The Contractor's recognized best practice shall govern, except as herein otherwise provided.

The plans, drawings and detail specifications attached to and forming a part of these specifications are:

....

....

....

....

....

12. Material and Workmanship.

When it is necessary or desirable to use apparatus not heretofore in use, the Contractor shall submit drawings of the same with his proposal and the acceptance of such proposal shall constitute acceptance of such new devices.

All material and workmanship shall be first-class in every respect.

The Contractor shall furnish for replacement, free of cost, f. o. b. works, any apparatus or material of his own manufacture, or furnished on his specification which, when used for its intended purpose, shall prove defective within a period of one year after having been placed in service. Defective material will be returned upon written request and at the expense of the Contractor.

The Contractor's standard apparatus shall be used, except as herein otherwise specified.

Electric apparatus shall withstand an insulated test at the works of three thousand (3,000) volts A. C. applied for one minute.

All magnets and solenoids shall be plainly marked with their resistance and the size of wire with which they are wound.

Field coils of motors and all other magnet windings of mechanism shall be securely held to prevent vibration.

12. Material and Workmanship—Continued.

NOTE.—It is recommended that all windings for apparatus for electric interlocking shall be treated by a thorough impregnation process to resist moisture and improve the insulation.

13. Transportation.

The Purchaser will .... furnish transportation for the men engaged in, and necessary tools and material required for, the installation of the plant over the following railway lines:

....

....

....

SHIPMENT AND HANDLING.—Tools and material are to be shipped
To ....
Care of ....
At ....
Via ....
Marked ....
Freight prepaid to ....

The Purchaser will unload and properly house only such material as arrives in advance of the Contractor's men.

The use of the following cars will be permitted under the restrictions of Articles Nos. 6 and 16, unless otherwise indicated in this paragraph:

	Number.	Furnished by
Motor cars	....	....
Velocipede cars	....	....
Handcars	....	....
Pushcars	....	....

When the Contractor is not permitted to use handcars or pushcars, the Purchaser will, at its own expense, distribute all material to the point of use upon receipt of notification from and under supervision of Contractor's Foreman.

The Contractor shall call upon the Purchaser for the required number of cars for the return of tools and unused material, and same will be furnished in .... days, after which time the Purchaser will, at its own expense, care for and load all tools and material.

14. Track Work.

The Purchaser will furnish:

All switches, derails and movable point frogs in place adjusted to the required throw.

All ties in place required for the support of the apparatus.

All rail braces and will install all except those located on the plates furnished by the Contractor.

All insulated rail joints in place.

The Purchaser will move all ties which interfere with installation of the interlocking apparatus or connections.

14. Track Work—Continued.

The Purchaser will remove all guard rail clamps, rail braces, anti-creepers and lips and otherwise prepare the rail for installation of detector bars.

The Purchaser will remove and replace all switch and tie rods (other than front rods on interlocked switches) requiring a change in location, the application of insulation, adjustment brackets or other alterations.

15. Obstacles.

The Purchaser will do all preliminary grading, provide adequate drainage and blast and remove all solid rock that will interfere with the placing of the interlocking apparatus or connections.

The Purchaser will furnish all extra labor and material required to place apparatus or connections in or under all platforms, roadways or walks, the location and construction of which are not herein specified.

16. Traffic.

The Contractor shall not unnecessarily delay or interfere with traffic. When it becomes necessary for Contractor to perform any work which may interfere with or endanger traffic, the Contractor shall notify the Purchaser and shall not proceed with said work until traffic is protected.

The Purchaser will promptly arrange to protect traffic upon request of Contractor.

17. Completion.

The Contractor shall notify the Purchaser, in writing, not less than seven (7) days before the plant will be ready for service.

The Contractor shall put the plant in service under the supervision of the Purchaser, and shall leave .... competent men on duty for .... hours thereafter.

The Purchaser will maintain and operate the plant as soon as it is put in service.

The Purchaser will put the plant in service, providing this cannot be done within three (3) days after the completion of the Contractor's work.

The Contractor shall remove and dispose of all excess earth and all refuse made by the Contractor's men or shall load on cars, where disposal cannot be made on right-of-way within interlocking limits.

18. Provided by Purchaser.

a ....

b ....

c ....

d ....

e ....

NOTE.—Items to be provided by Purchaser should be assembled and filled in at this point.

19. Tenders.

Sealed tenders for the work covered by these specifications will be received:

by ....

at ....

up to......hour of the......day of......month......of........at which time and place said tenders will be opened. Bidders are invited to be present.

Tenders shall be divided as follows:

NOTE.—This space is provided for a complete description of the manner in which the tenders are to be divided for the different portions of the work.

a ....

b ....

c ....

d ....

The Purchaser reserves the right to reject any and all bids.

20. Tower.

A........building for tower........stories high, and ....x ...., inside dimensions, shall be built by the........in accordance with specifications and drawings........for building and drawings.... ....for frame.

NOTE.—In erecting a wooden tower provision should be made for leadout wires in an asbestos lined or........lined chase, accessible for its entire length. Not less than fifty (50) per cent. of the capacity of the chase shall remain free for the further installation of wires.

When fireproof towers are erected a special chase for entrance of wires should be provided.

21. Power House.

A........building for power house........stories high and........ x.........., inside dimensions, shall be built by the..........in accordance with specifications and drawings..........for building and drawings..........for frame.

22. Foundations.

..........foundations for the buildings shall be built by the ....in accordance with specifications and drawings..........

23. Gasoline Tanks.

Housing for gasoline tank as per drawing.........., located not more than..........ft. from the power house, will be built by..........

24. Lighting.

The number, kind, size and distribution of electric lamps shall be as follows:

Room.	Number.	Candle-power.	Location and Description.
Operating Room			
Lower Story			
Battery Room			
Generator Room			
Special			

Lights shall be controlled by switches located as follows:

Number.

........................Operating Room Lamps........................
........................Lower Story Lamps ....
........................Battery Room Lamps ....
........................Generator Room Lamps........................
........................Special Lamps ....

Fixtures for electric lamps will........be required. When required they will be provided by Purchaser and installed by Contractor.

The electric lights and accessories shall be acceptable to and installed under the rules of the National Board of Fire Underwriters and the attached requirements of the local authorities.

25. Appurtenances.

Except as otherwise specified, all tools, fixtures for buildings, and supplies required for the operation of the plant will be furnished by Purchaser.

POWER PLANT.

30. Composition and Location.

The power plant shall consist of:
............................engine ....connected to ....motor ....connected to ....generator ....transformer, together with.........mercury arc rectifier....................charging rheostat...................... operating switchboard..................motor starting panel............ and.................storage batteries, each composed of..........cells, all in accordance with detailed specifications herein and shall be installed by the.......................in the locations provided by the ....

31. Engine.

A .... cylinder .... cycle

Vertical
Horizontal } .... engine of.................brake H.P.
Turbine

manufactured by .... installed by the ....
shall be furnished on a ....foundation to be furnished in place by the ....built in accordance with the standard specifications of the.....................and plans of the manufacturer of the engine dated ....

A complete set of wrenches shall be furnished.

NOTE.—This space is provided for detailed specifications of engine to be used.

(a) ....
(b) ....
(c) ....
(d) ....
(e) ....

NOTE.—The engine should be of such type as to be easily accessible for attention to bearings, adjusting and cleaning.

NOTE.—For power interlocking work, as a simple and desirable method of operation, a constant rate of charging for the storage battery is taken as the basis for the establishment of the recommended capacity ratios between the battery, the generator and the engine.

GASOLINE ENGINE SPECIFICATIONS.

The recommended brake horse power of the gasoline engine shall be not less than one and three-quarters times the kilowatt capacity of the generator at the maximum voltage and the eight hour charging rate.

The engine shall run without injurious vibration and shall operate continuously at manufacturer's specified capacity for a period of sixteen (16) hours without injurious heating in any part.

Regulation in speed shall be within three (3) per cent. from no load to full load and the regulation as recorded on the voltmeter for a given current shall not vary more than two (2) per cent. between impulses.

Electrodes on the engine for electric ignition shall be tipped with platinum or an equally serviceable material.

The manufacturer's standard exhaust muffler shall be provided.

The engine and accessories shall be accepted to and installed under the rules of the National Board of Fire Underwriters and the attached requirements of the local authorities.

Engines of twenty-five (25) H.P. or less shall not exceed a speed of four hundred revolutions per minute.

31. Engine—Continued.

A gasoline tank of.............gallons capacity shall be furnished. Both fuel and cooling tanks shall be made of iron or steel with brazed or riveted seams. All tanks shall be dipped in the galvanizing kettle after they are put together.

Sufficient piping shall be furnished to locate the gasoline tank ....ft. from the engine.

Unions in all piping shall be equipped with ground brass seats.

NOTE—For tanks both for fuel and water it is recommended that selection shall be made, when practicable, from the following table:

GASOLINE TANKS FOR RAILROAD WORK.

Gallons Capacity.	Inches in Diameter.	Inches in Length.	Gage of Metal.	
			Head.	Body.
66	18	68	No. 14	No. 16
120	24	66	No. 12	No. 14
500	36	120	No. 10	No. 12

As a guide in ordering tanks it is good practice to consider that it will require one-tenth ($\frac{1}{10}$) of a gallon of gasoline per H.P. hour for gasoline engines.

For cooling the minimum of free running water should not be less than ten (10) gallons per H.P. hour and for the circulation tank system not less than fifty (50) gallons per H.P.

Unless otherwise specified, an iron or a steel cooling tank of sufficient capacity for a continuous run of ten hours on one filling, with connections and removable cover, shall be furnished. Connections between engine and tank shall be arranged for convenient and complete drainage of the cooling system, for independent drainage of the engine and tank, and to conduct all waste water and steam to the outside of the building.

32. Generator.

The generator shall be shunt wound, self-excited, shall have self-oiling bearings, carbon brushes, rheostat, and when belt connected, a belt tightener, sub-base and pulley.

The normal or rated speed shall not exceed 1,500 R. P. M., except when direct connected to an A. C. motor or steam turbine.

The generator shall have a continuous current capacity equal to the eight hour rate (......Amp.) of the battery, at a voltage equal to the maximum voltage (......volts) of the battery on charge, without a rise in temperature in any part exceeding 40 degrees C. (72 degrees F.), above the temperature of the surrounding atmosphere. It shall be so wound that its voltage at the continuous current rating given above may be varied by means of a field rheostat from the minimum to the maximum charging voltage of the battery. The generator shall be capable of supplying for four hours a current output twenty-five (25) per cent. in excess of the continuous current capacity referred

32. Generator—Continued.

to above without a rise in temperature in any part exceeding 50 degrees C. (90 degrees F.) above the temperature of the surrounding atmosphere.

It is understood that the temperature of the surrounding atmosphere is to be based on 25 degrees C. (77 degrees F.), but should the temperature vary from this, corrections shall be made in accordance with the recommendations of the American Institute of Electrical Engineers.

The current output of the minimum allowable generator shall be that required for the operation of two switches simultaneously.

With the brushes in a fixed position, the generator shall be practically sparkless under all operating conditions as outlined above.

NOTE.—These generator specifications will fix a machine which in normal power interlocking service will have an ample overload capacity to meet general requirements.

33. Motor.

The motor shall be..........H.P., with a rated speed not to exceed 1,500 R. P. M., if direct current, or 1,800 R. P. M., if alternating current, and shall have automatic regulation to within 20 per cent. when operating on........to........volts, D. C., or on........to........volts ....cycles, ...phase A. C., shall conform to generator specifications regarding heating, sparking and insulation, and shall be furnished with a starting panel.

34. Motor Generator.

Motor generators shall be direct connected, mounted on a cast iron sub-base and shall conform to the specifications for motors and generators.

35. Transformers.

36. Storage Battery.

(1) The storage battery shall consist of............cells A. H. Capacity..........type at eight hour rate..........with glass jars manufactured by................or

(2) The storage battery shall consist of...........cells manufactured by................of sufficient capacity to operate the interlocking plant, together with all accessories which obtain a current supply from the main battery, electric lighting..........included, for a period of ....days on one charge, on the basis of............lever movements and of lights burning..........hours per twenty-four hours.

Batteries up to four hundred A. H. capacity shall be placed in glass jars. All batteries shall be rated for an eight (8) hour discharge at 70 degrees F.

NOTE.—For a battery of a capacity greater than four hundred A.

36. Storage Battery—Continued.

H., wooden tanks should be required and should be covered by special specifications.

NOTE.—It should be borne in mind both that the capacity of a storage cell decreases with a decrease in temperature and that the extent of such decrease should be obtained from the manufacturer, and also that the number of days of excess capacity for the battery to be allowed should be stated and depends upon conditions of maintenance and operation, for example, frequency of visits of maintainer.

The cells shall be connected by lead covered bolts. Burnt connections shall be used when specified. The rows of cells shall be connected together by lead strips of as great a sectional area as the connections between cells, or by lead coated copper connections of equivalent carrying capacity. Such connections shall be considered a part of the battery.

A plan showing separate battery room shall be furnished the Contractor.

The battery shall be installed with a minimum vertical clearance of thirty inches above the jars and so as to permit the removal of any element without disturbing its containing jar or adjacent cells. Unless otherwise specified, the battery shall be easily accessible from both sides for inspection and attention. Plates shall be arranged transversely with the rows.

The battery shall be provided with..........sand trays which shall be so constructed as to prevent the leakage of sand to the lower cells.

The insulators supporting the sand trays shall rest on wooden racks treated with an acid-proof paint.

The racks shall be supplied in place by the..........in accordance with the standard plans of the............, ...hydrometers and ....extra jars shall be provided.

The initial charge of the battery shall be conducted by..............

The instructions of the manufacturer shall be followed during this initial charge and a copy of the readings which are taken during the charging period shall be sent to him.

The................shall provide current at the proper voltage for the initial charge.

37. Switchboards.

GENERAL.—Switchboards shall be made of oil-finished slate not less than one (1) in. thick and free from metallic veins or flaws.

They shall be of ample size to accommodate all the instruments, switches, etc., required for the operation of the plant.

They shall be supported on substantial iron frames and mounted, when not more than twelve (12) in. wide, not less than fifteen (15) in. from the wall.

NOTE.—The distance between a switchboard and the wall depends on the width of the board and the voltage employed.

37. Switchboards—Continued.

They shall be acceptable to and installed under the rules of the National Board of Fire Underwriters and the attached requirements of the local authorities.

The finish of all fittings on each switchboard shall be uniform where practicable.

All switches shall be substantially constructed and so mounted as to preserve their alinement.

Each switch shall be provided with a plate designating the circuit which it controls.

National Standard enclosed clip fuses of the required capacity shall be provided for all circuits not otherwise protected.

Power Board.—The power board shall be equipped with one......... ammeter and one..........voltmeter, ammeter to be arranged to show current in any circuit. The use of external multiple shunts will not be permitted.

Where duplicate charging sets are used a voltmeter switch shall be provided for connecting meter to either generator.

A no-load reverse-current circuit-breaker shall be provided in the battery charging circuit.

The generator field rheostat shall be mounted on.................. of board.

Motor Starting Panel.—Starting box for D. C. motors shall be designed to protect the motor from overload, both in starting and running positions, and in case of failure of the line voltage or opening of the field circuit shall return automatically to the "off" position.

The resistance shall be proportioned to start the motor without excessive rushes of current and without overheating.

The manufacturer's standard devices shall be furnished for starting A. C. motors.

Operating Board.—The operating board shall be equipped with a ....ammeter, arranged to show current in the operating and also in auxiliary circuits when used. The use of external multiple shunts will not be permitted. When low voltage auxiliary circuits are used, the ammeter shall be provided with high and low reading scales.

The operating board shall be provided with one 2 candle power lamp for detecting grounds, and one 2 candle power lamp for illuminating ammeter scale.

Binding posts, with two nuts and two washers each, shall be provided on bottom of operating board, for all external connections.

The operating board shall be provided with one (D. P.) / (S. P.) knife switch and...............the National Standard enclosed fuses for the control of each signal lighting circuit where same are required.

MACHINE.

40. Capacity.

The interlocking machine shall have:

............levers for............one-arm high signals.
............levers for............two-arm high signals.
............levers for............arm high signal.
............levers for............one-arm dwarf signal.
............levers for............two-arm dwarf signal.
............levers for............switches and derails.
............levers for............movable point frogs.
............levers for............crossing bars.
............levers for............lock levers.
............levers for............spare spaces.
................................spare spaces.
................................Total spaces.

41. Locking.

The machine shall be provided with mechanical locking of the preliminary type, so designed as to prevent the manipulation of levers for conflicting routes.

Space for one locking bar the full length of machine shall be provided in the locking bed for each spare space or spare lever. Locking shall be so arranged as to be easily accessible.

42. Levers.

Levers shall be numbered to correspond with attached plans. Normal and reverse latches shall be provided.

Lever handles shall be of Purchaser's standard color, as per following table:

Home signal levers, vermilion.
Distant signal levers, lawn green or lemon yellow.
Lock levers, blue.
All other levers, black.

43. Indication.

Each lever shall be provided with a device to insure correspondence in the movement of the lever and that of the unit controlled thereby before the release of the mechanical locking can be effected.

Levers shall be free to move between their indicating positions.

44. Terminal Board.

The machine shall be provided with a slate terminal board, having binding posts for making all connections leading from the machine, and fuses for the protection of the circuit for each operated unit.

45. Case.

The machine sha'l be enclosed in a case to prevent improper manipulation.

50. General.

All signals shall be of the iron pole and semaphore type with mechanism enclosed in iron case.

Signals shall conform as to location and dimensions to the Railway Signal Association standards.

All motors in place shall be of sufficient capacity and mechanism constructed to perform complete operation of a ninety (90) degree signal of Railway Signal Association standard, when not more than........ ft. from interlocking machine, in not more than............seconds with battery at ten (10) per cent. below normal voltage.

The normal voltage of battery is one hundred and ten (110).

NOTE.—It is recommended that fair working conditions consist of a distance of thirty-five hundred (3500) ft. from interlocking machine and seven (7) seconds time of complete operation.

51. Lanterns.

The Purchaser's standard {oil / convertible} lanterns, as manufactured by........................shall be furnished by......................

52. Arms and Spectacles.

High signal arms shall be..........ft. long, ... in. wide at outer end, and made of well seasoned clear white ash, or equally good material.

Dwarf signal arms shall be flexible or hinged, and...........in. long.

Painting of blades shall be as shown on Drawing No............, dated..............., attached.

The Purchaser's standard signal spectacle castings shall be used, as shown on Drawing No........, dated............, attached.

Roundels shall be solid color, one-fourth (¼) in. thick, and supplied as follows:

Caution, color ...., Dia......................in.
Stop, color ...., Dia......................in.
Proceed, color ...., Dia......................in.
Dwarf, color ...., Dia......................in.
Back, color ...., Dia......................in.

Color density of roundels shall be as per attached specifications of the Purchaser, or shall be within the following limits:

			....Scale.	
Color	.............Scale		...............Scale.	
Red	...............to	....	...............to	....
Green	.............to	....	...............to	....
Yellow	............to	....	...............to	....
Blue	..............to	....	...............to	....
Purple	.............to	....	...............to	....

53. Foundations.

Foundations shall be made of concrete, and in general conform to the Purchaser's standard, as shown on............plan No............, dated................, attached.

Dimensions of top of signal foundations shall be six (6) in. greater than dimensions of bottom of mechanism case or base of signal.

The minimum foundation shall have a top surface two and one-half (2½) ft. square, a bottom surface three and one-half (3½) ft. square, with a vertical height of four (4) ft.

Concrete shall be mixed in the following proportions:

....

....

....

Anchor bolts for high signals shall be one (1) in. in diameter and three (3) ft. long.

Anchor bolts for signal brackets shall be one and one-quarter (1¼) in. in diameter and four (4) ft. long.

Ladders shall be provided with............foundations, as shown on Drawing No........, dated............, attached.

54. Electric Lighting.

Electric lighting of signals will........be required.

Convertible lanterns shall be equipped with..........candle power incandescent lamps and marine receptacles, in accordance with.......... Drawing No........, dated...................., attached, also with oil fonts and burners. ....extra incandescent lamps shall be furnished.

Electric lights on signals shall be arranged on..............circuits as follows:

(Distribution and grouping of lights for each circuit to be shown in this space.)

SWITCHES.

60. General.

Switch mechanisms shall perform their normal operations in the following sequence:

1. Unlock switch.
2. Throw switch.
3. Lock switch.
4. Indicate.

All motors in place shall be of sufficient capacity and mechanisms constructed to perform complete operation of normal and reasonably free working switch in not more than four (4) seconds at a distance from interlocking machine of not more than........ft., with battery at ten (10) per cent. below normal voltage. The normal voltage of battery is 110.

NOTE.—It is recommended that fair working conditions consist of a distance of one thousand (1,000) ft. from interlocking machine.

60. General—Continued.

Mechanisms shall be so constructed and equipped that switch can be stopped or reversed at any point of movement by manipulation of lever controlling same.

Mechanism shall be equipped with an efficient friction clutch to prevent damage to same in case movement of switch is obstructed. If friction clutch fails to release motor, all parts of mechanism shall be strong enough to permit of stopping the switch at any point of its movement by introduction of an obstruction between point and stock rail without injury to any part.

Staggered locking shall be provided for the normal and reverse position of the points.

The hole or notch in lock rod shall be not more than one-sixteenth ($\frac{1}{16}$) in. larger than plunger measured in a horizontal line.

NOTE.—It is recommended as a safe and better method of operation that a rectangular lock rod be employed with a vertical locking face of a height as great as practicable. Consideration should be given to the substitution of better wearing and stronger materials for those at present employed in the locking edges and surfaces of the plunger and lock rod, and endeavor should also be made to, in the best practical way, secure as great an engaging area as possible when the lock rod is moved three-thirty-seconds ($\frac{3}{32}$) in. out of lock position.

Switch mechanism shall be protected by substantial iron covers fastened to ties or mechanism with wrought or malleable iron fastenings, in a manner to permit of convenient inspection of mechanism.

The location of switch operating mechanism shall be as shown on ....Plan No........, dated............., attached.

All parts of mechanisms and covers shall be placed outside of clearance limits, as shown on diagram on...........Plan No........, dated ...., attached.

61. Mechanical Connections.

The mechanical connections for switch mechanism shall be arranged in accordance with Contractor's standard practice, unless otherwise provided.

Strength of connections shall be such that switch points can be stopped by placing an obstruction between point and stock rail at any part of stroke without breaking or bending any such connections.

Both the operating rod and the lock rod shall be of sufficient strength to alone and independently hold the switch points in position.

Connections shall be strong enough to prevent bending or breaking in case mechanism is operated when detector bar is engaged by wheels of a car or engine.

When either pipe, pipe joint material, pipe carriers, compensators, cranks or other such material are used in connections between movements and detector bars, such material shall conform to the Mechanical Interlocking Specifications of the Railway Signal Association.

61. Mechanical Connections—Continued.

All ties whose relative location affects the correct operation of mechanism shall be securely strapped together, as shown on Purchaser's Plan No........, dated................, attached.

62. Detector Bars.

Bars shall be located as shown on..............Plan No........, dated................, attached, unless otherwise specified.

NOTE.—Bars on curves should be located on inside, outside or both sides of curve, or as determined by local operating traffic conditions.

Detector bars shall be arranged to give fifty-three (53) ft. continuous protection for all switches, derails, movable wing and movable point frogs.

When used on outside of rail, detector bars shall be made of one-half by two and one-quarter (½ x 2¼) in. wrought iron or steel, and have one beveled edge, square ends and bolted joints. Full length bars shall be made up in eighteen (18) ft. sections.

Bars shall be drilled one (1) in. from bottom of bar to center of hole for three (3) one-half (½) in. countersunk head bolts or rivets. The first hole shall be one (1) in. from end to center and two (2) in. between centers of holes. Where splice plates are specified, they shall be made of wrought iron or steel one-half by two by twelve (½ x 2 x 12) in., riveted at the end of bar with three (3) one-half by one and one-eighth (½x1⅛) in. countersunk head rivets and attached to intermediate adjacent sections by three (3) one-half by one and one-half (½x1½) in. countersunk head bolts, with nuts held in place by nut locks.

Driving pieces shall be made of wrought iron or steel arranged for one and one-quarter (1¼) in. jaw connections. The part where the jaw is connected shall be three-quarters by two by three (¾ x 2 x 3) in., and part riveted to bar shall be one-half by two by six (½ x 2 x 6) in., drilled for three (3) one-half (½) in. rivets, one (1) in. from end and two (2) in. between center of holes. Offset from bar to jaw connection shall be one and one-half (1½) in.

Driving pieces shall be placed midway between two (2) clips in space not occupied by joint, and the driving rod shall have not more than seven (7) ft. of its length unsupported.

Fifty-three (53) ft. bars shall be mounted on seventeen (17)...... type rail clips, and a proportionate number of clips shall be used for longer or shorter bars.

Centers of rail clips shall be placed eight (8) in. and twenty-six (26) in., respectively, from ends and the remaining clips approximately four (4) ft. apart.

Where radial arm clips are used combination bar stops and guides shall be provided for every ten (10) ft. of bar (equally spaced), and not less than two (2) such stops on one bar.

Bars shall be mounted substantially and operated close to head of rail in a plane inclined toward the center of track.

62. Detector Bars—Continued.

Bars shall rise a minimum of three-quarters (¾) in. above top of rail at every point before the unlocking of the switch, and shall rest one-quarter (¼) in. below top of rail when lever travel is completed.

Detector bars, when practicable, shall be so connected that the unlocking movement when switch is in the main line position shall be in the reverse direction to the facing movement of traffic over the points.

Where rocker shafts are used, they shall be made of two (2) in. square cold rolled steel with movable bearings and crank arms. Arms shall be...........iron and nine (9) in. center to center. The bearings shall be securely bolted to ties with four (4) three-quarter (¾) in. bolts. The maximum spacing of supports shall be six (6) ft. centers.

Other detector bar fittings, where required, shall be Railway Signal Association Standard.

Detector Track Circuits.—Detector track circuits will.........be required in addition to / lieu of } detector bars.

When detector track circuits are required, they shall conform to the following specifications:

Note.—Detail specifications to be given here for results required of detector track circuits as to control of switches, etc.

....

....

....

....

Note.—Reference is made in Section 100 to various purposes to which such circuits may be applied.

63. Switch Circuit Controllers.

Circuit controllers of substantial construction and positive in action shall be provided for each switch mechanism, and shall be so constructed that they can be maintained to make or break circuit when switch point shall be moved from the closed position three-sixteenths (3/16) of an inch.

Operating rods of switch circuit controllers shall be one (1) in. in diameter and adjustable, with a maximum distance apart of supports of three (3) ft.

Note.—Consideration should be given to the question of the connection of the circuit controller to the switch, as to whether one or both points shall be positively connected, and if but one point, which shall be selected. It is recommended that circuit controller be insulated from tie plate and switch point.

WIRE AND WIRING.

70. Specification.

All wire shall conform to the standard specifications of the Railway Signal Association.

71. Size.

All wires shall be of sufficient size to permit operation of switch and signal mechanism in accordance with previous specifications.

71. Size—Continued.

Rubber covered wire smaller than No. 14 B. & S. shall not be used.

Copper line wire smaller than No. 10 B. & S. shall not be used.

72. Tagging.

All wires shall be tagged at all junction boxes, switches, signals, relay boxes, arrester boxes and at all line wire connections.

All tags shall be made of vulcanized sheet fiber not less than one-sixteenth ($\frac{1}{16}$) in. thick, firmly attached to the wire by best quality tarred yacht marline one-sixteenth ($\frac{1}{16}$) in. in diameter.

The tag shall have a stamped imprint to show the functions of the wire.

73. Runs.

Wires shall be laid loosely in trunking without stretching or crowding.

All wires shall, as far as practicable, be continuous without joints or breaks between interlocking machine and the unit operated; joints when made shall be in junction boxes and only made on permission from Supervisor.

In submarine cable work spare wires up to twenty-five (25) per cent. of the number in use shall be provided as specified. When spare wires are required in other than cable work the number and size shall be specified.

74. Common.

Unless otherwise specified, common wires shall be continuous without joints or breaks from interlocking machine to the limits of the interlocking plant.

Reductions in size of common wire and connections to pole lines shall be made in junction boxes.

All connections between branches and main common wires shall be made in junction boxes, with combination clamps and terminals mounted on slate bases.

But one unit shall be connected to one branch from the common wire.

No common wire shall be less than No. 12 B. & S. gage.

75. Joints.

Joints must be made as follows:

Braid shall be pulled back one (1) in. from end of rubber on each side of splice, and rubber cut with knife held at an angle of approximately thirty degrees with axis of wire, as one would sharpen a pencil.

After removing rubber, wire shall be thoroughly cleaned, care being taken to prevent injury from small cuts or nicks.

Wire, after being cleaned, will be twisted together in the form of a regular line wire splice, turns being spaced approximately one-sixty-fourth ($\frac{1}{64}$) in.

Joints shall then be soldered by pouring on, or dipping wire into,

75. Joints—Continued.
melted solder, a non-corrosive rosin flux being used. After soldering, joints shall be painted with..........insulating paint or with............ compound. Joints will then be covered with two layers of.............. insulating tape between ends of braid, which tape shall be heated sufficiently to form a tight covering but not enough to injure the quality of the material. Coating of............insulating paint or.............. compound shall be put on over insulating tape and two layers of........ adhesive or friction tape shall be applied, after which the outside of joint is to be painted with............insulating paint.

WIRE PROTECTION.

80. Trunking and Conduit.

Trunking, when on stakes above ground and running parallel with the track, shall not be placed nearer than six (6) ft. from the gage side of the nearest rail except by special permission.

Local conditions shall determine the height of trunking when above ground; in general, when trunking is run parallel with the tracks, bottom of trunking shall be placed approximately six (6) in. above the ground.

The location of the main runs of trunking is shown on Plan No...., dated................, attached.

NOTE.—Permission should be obtained to place between tracks run of trunking parallel with the tracks.

MATERIAL.—All grooved trunking, built up trunking and all capping, as specified, shall be made in accordance with Railway Signal Association drawings for standard wood trunking, dated July 8, 1908, attached.

Commercial sizes of lumber shall be used, finished on one side and two edges.

Where slight changes in dimensions of grooved or built up trunking are necessary, either due to failure of the commercial lumber to run to exact sizes or due to finishing of the surfaces, such changes shall be allowed for in the walls of groove, the groove remaining exact size throughout.

As specified, capping shall be securely fastened to trunking with

.... { gate hooks. / nails.

NOTE.—It is recommended that gate hooks be used on main runs of trunking and nails on cross leads.

Nails shall not be driven through the trunking from the inside of the groove nor shall they be driven into the groove from the outside.

Drainage of the trunking shall be provided as follows:

....

....

....

Inside corner of trunking, at turns, must be rounded to prevent insulation on wires being injured.

80. Trunking and Conduit—Continued.

Not less than one-third (1/3) of the capacity of the groove shall remain free for the further installation of wires.

Surfaces of trunking that are to be painted shall be finished.

Treated trunking must be used when specified, and shall comply with the requirements as to treatment which are attached.............
....
....
....

When specified, the wires in the trunking shall be loosely bound and shall be so laid in pitch as to be practically free of contact with all walls of the trunking. Pitch as used must not crack at a temperature of........degrees F., and must not melt at a temperature of........ degrees F. It must neither contain any material nor be applied at a temperature which will injure the rubber insulation.

Boot-Legs.—Boot-legs for track connections shall be made according to ....Plan No.........., dated.............., attached, and shall be securely fastened to the trunking not less than two (2) in. from base of rail, and shall not extend more than one (1) in. above base of rail.

Joints.—Except as otherwise shown in drawings which have been furnished, all joints in grooved trunking shall be lapped, the ends of trunking being beveled at an angle of forty-five (45) degrees.

When trunking is built up all joints shall be staggered.

All joints in capping shall be made at least one (1) ft. from joints in trunking.

81. Supports.

Trunking above ground shall be supported on stakes placed not more than five (5) ft. centers.

Except as shown on attached drawings, stakes shall be made of ....three (3) in. by four (4) in., or of equivalent circular section, and of sufficient length to allow them to be placed at least two (2) ft. in the ground. When, due to local requirements, such as contour of the ground or other physical conditions, stakes of a greater length than three (3) ft. six (6) in., or a greater cross-section than three (3) in. by four (4) in. will be necessary, information as to the number, length and cross-section of such will be furnished by the Purchaser to the Contractor.

All stakes supporting trunking shall be placed vertically and extend at least two (2) ft. below the surface of the ground, unless otherwise specified.

A piece of capping eight (8) in. long and the width of the trunking shall be placed between the trunking and each stake.

All joints in the bottom of the trunking shall be supported by stakes.

81. Supports—Continued.

Where trunking exceeds a width of seven (7) in. a special arrangement consisting of { a double line of stakes / a single line of large } stakes shall be installed, or provision shall be made as follows..................................
....
....

82. Junction Boxes.

LOCATION.—Junction boxes shall be located as shown on............ Plan No........, dated..................., attached (which also shows general runs of trunking), and at a height sufficient to allow terminals to be placed at least six (6) in. above top of trunking.

When so indicated on plan, junction boxes shall be supported in the same manner as the trunking.

MATERIAL.—Junction boxes shall be made of..................and so designed that terminals will be kept dry. Each junction box shall be fitted with a cover, hasp and staple suitable for the Purchaser's standard lock, No........, made by..........................

SIZE.—Where ten (10) or less wires are used, junction boxes shall be sixteen (16) in. square by twenty (20) in. deep inside dimensions, and shall be increased six (6) in. in length for each ten (10) or fraction thereof additional connections made in the box.

83. Lightning Arresters.

Lightning arresters of............design shall be used at all aerial line connections.

Lightning arresters shall be grounded through two (2) No. 8 B. & S. gage copper wires (insulated above ground), wrapped around and soldered to a galvanized iron ground rod not less than one (1) in. in diameter, driven eight (8) ft. into the ground.

Where such ground connection is not satisfactory the desired protection for each point shall be specified by the Purchaser and furnished in place by the..................................

84. Fuses.

The necessary fuses to properly protect all apparatus and circuits shall be installed.

Double pole fuse cut-out shall be provided for each circuit on the power board.

An additional double fuse cut-out shall be placed in storage battery leads as near as possible to battery terminals.

CIRCUITS.

90. General.

All circuits shall conform to the Contractor's recommended practice unless otherwise specified.

91. Signals.

All high and intermediate speed signals shall be so controlled by circuit breakers on all facing derail, switch and frog points over which they govern, that unless such points are in proper position and locked the signals will assume the stop position. Low speed signals shall be controlled by facing point derails in the same manner.

Each distant signal shall be controlled by circuit breakers on all signals, the indication of which it repeats, and so arranged that the circuit to the distant signal is broken unless all signals for the track governed are in proceed position.

All non-interlocked single main line switches, both ends of crossover switches and siding derails between home and distant signals shall be protected by switch circuit controllers.

92. Switches.

The circuits for facing point derails shall be controlled by normally closed circuit breakers on all signals governing over them.

93. Cross Protection.

Protective circuits shall be so arranged as to:

(a) Automatically disconnect any unit or units improperly supplied with power.

(b) Prevent the restoration of power until the trouble is removed.

(c) Cause an operative failure in event of any failure in the protective circuit.

94. Switchboard.

The Contractor's recommended arrangement of circuits shall be followed, subject to necessary modifications on account of special requirements.

95. Electric Lighting.

96. Special.

NOTE.—The Purchaser will here indicate in full detail all special circuit requirements.

(a) ....

(b) ....

(c) ....

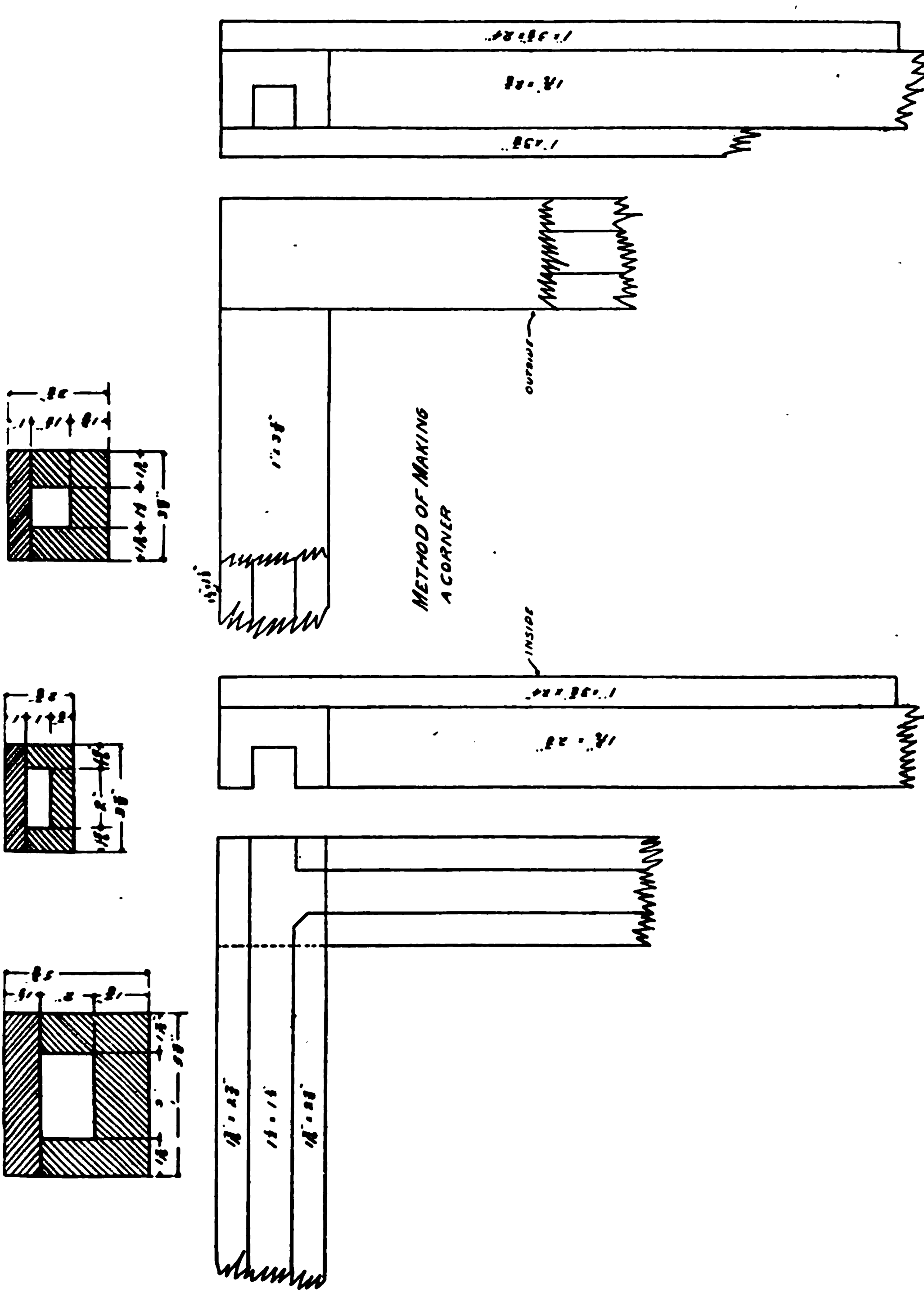
(d) ....

(e) ....

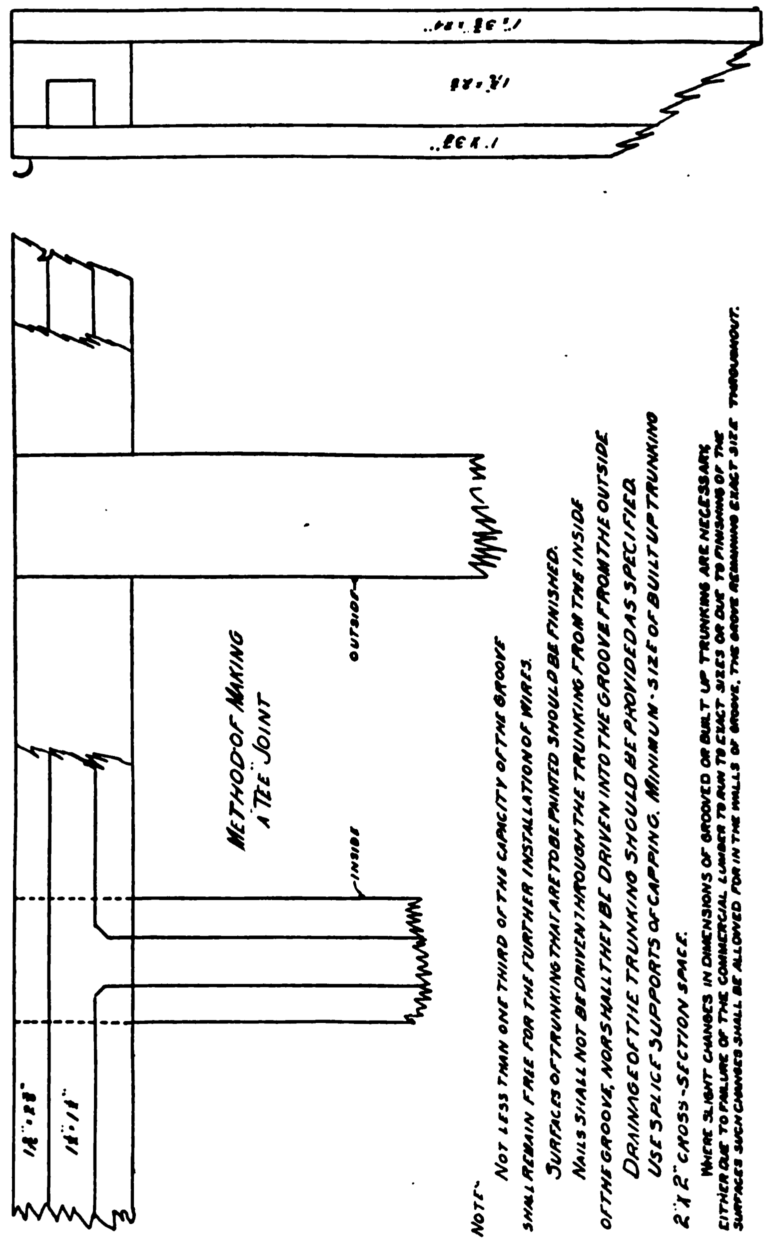
TRACK CIRCUITS.

100. General.

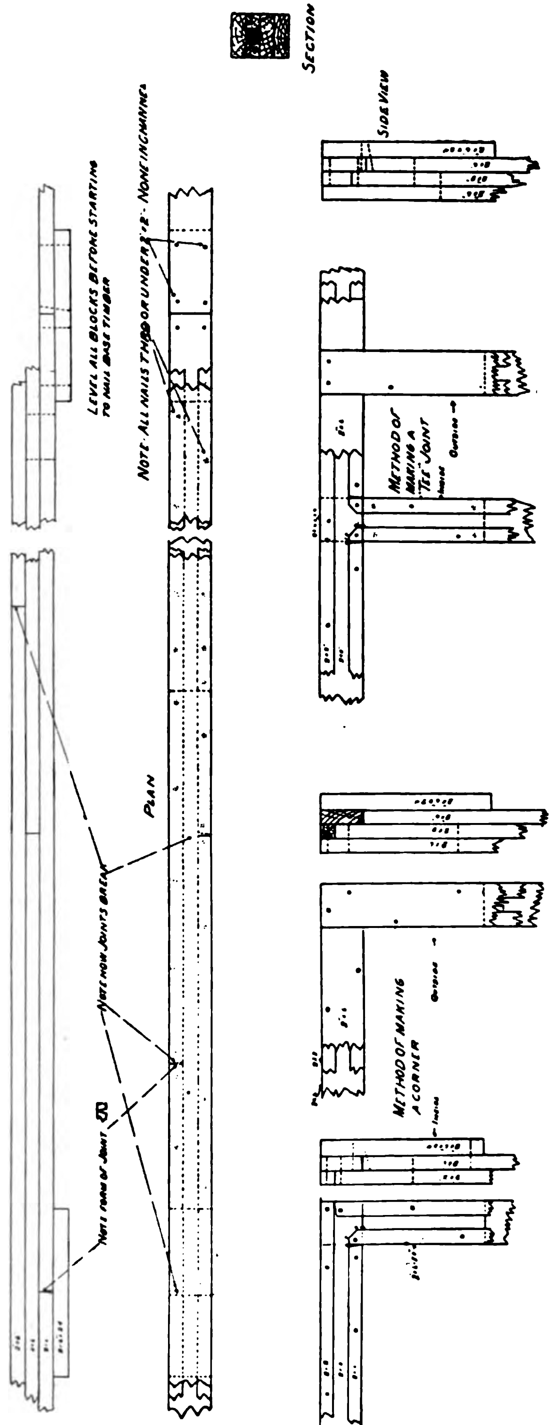
The Contractor shall provide.............track circuits as shown by the shaded tracks on Purchaser's plans. The purpose or purposes of each track circuit will be indicated on the plan by one (1) or more of the following letters:



ELECTRIC INTERLOCKING—STANDARD WOOD TRUNKING.



ELECTRIC INTERLOCKING—STANDARD WOOD TRUNKING.



ELECTRIC INTERLOCKING—STANDARD WOOD TRUNKING.

100. General—Continued.

Number.

S............for control of semi-automatic signals.
D............in place of or in addition to detector bars.
F............for control of fouling point indicators.
A............for control of annunciators.
R............for control of route locks.
B............for control of automatic block signals.
C............for control of highway crossing bells.

All sidings and siding crossovers shall be protected by shunt track sections extending to the fouling point of derail; main line crossovers shall be protected by as much shunt track section as can be obtained.

101. Bonding.

All rail joints, except as mentioned below, shall be bonded with two (2) No. 8 W. & M. gage (.162 in. diameter) E. B. B. galvanized iron wires........in. long.

NOTE.—There should be a specification submitted covering the manufacture of the material in the bond wires.

Bond wires shall be located outside of splices and at least one wire shall be on gage side of rails.

Each bond wire shall be fastened at each end into the web of the rail by a channel pin or bonding tube.

Bonding shall be completed on the same day that holes are drilled.

NOTE.—It is recommended that No. 6 B. & S. gage bare copper or copper-clad bond wires shall be used in tunnels and applied as above mentioned.

It is recommended that at joints in highway and street crossings and in station platforms that two iron or copper-clad bond wires shall be used on gage side of rail and two copper or copper clad wires on outside of rail and applied as above mentioned.

Frogs shall be bonded in the same manner as rail joints and shall be so connected that the continuity of the track circuit will be broken when they are taken from the track.

Pins or tubes shall be made of iron or steel coated with copper or tin and shall be of such length, shape and hardness that when driven into the rail in combination with the bond wire they will completely fill in cross-section a nine-thirty-second ($\frac{9}{32}$) in. hole in web of rail and will form a good mechanical and electrical connection.

The following types of channel pins or bonding tubes are satisfactory to the Purchaser...
....

Pins or tubes will be calibrated by the Purchaser.

A selection will be made from each package of pins for test.

A variation of the thickness of the pin or tube between the base of the groove at the center and the outer wall greater than one-sixty-fourth ($\frac{1}{64}$) in. will not be permitted, or else a variation either way

101. Bonding—Continued.

from the outside diameter of the standard pin or tube at center greater than one one-hundred-twenty-eighth ($\frac{1}{128}$) in. will not be permitted.

The entire shipment will be rejected should five (5) per cent. of the pins or tubes tested prove defective.

102. Insulated Joints.

Insulated rail joints shall be furnished by the Purchaser and installed by the Purchaser at joints designated by the Contractor.

Insulations for bridle rods shall be furnished by the..........and installed by the Purchaser at points designated by the Contractor.

Insulated tie plates and other insulated interlocking connections shall be furnished and installed by the.......................

Both rails shall be insulated at fouling points, ends of track circuits and in switch leads.

All rail joints to be insulated are..........lbs..........section, as shown on attached drawings, and as located on plan of tracks.

All switches to be insulated are equipped with..........bridle rods ....in. by..........in. cross-section, as shown on attached drawings, except as noted on plan of tracks.

103. Track Battery.

Each track circuit shall be operated by at least two (2) cells of gravity battery connected in multiple.

Jars shall be of glass, six (6) in. in diameter by eight (8) in. in height by one-eighth (⅛) in. thick.

Zincs shall be four (4) lbs., circular, amalgamated, with two (2) per cent. mercury supplied with brass terminal and suspended from three points; unless other types are specified.

Coppers shall be flat leaf with connecting wire riveted, and shall be so shaped that they will be held in place by the copper sulphate.

Three (3) lbs. of good copper sulphate, free from dust, shall be furnished with each cell.

NOTE.—Complete specifications for battery materials should be furnished by Purchaser, if practicable.

104. Battery Housing.

Unless otherwise specified, track batteries shall be housed in three (3) cell $\left\{\begin{array}{l}\text{cast iron}\\\text{concrete}\end{array}\right\}$ chutes............ft. deep, as per drawing attached, weighing for cast iron not less than three hundred (300) lbs. each. Each chute shall be provided with a three (3) cell elevator, rope, and if specified, a frost board.

105. Relays.

Relays shall conform to specifications of the Railway Signal Association dated October, 1906, a copy of which is attached.

106. Relay Housing.

When possible, relays shall be housed in the signal mechanism case; otherwise they shall be housed in weatherproof $\left\{\begin{matrix}\text{iron}\\ \text{wood}\end{matrix}\right\}$ boxes located as specified, in the tower, on signal bridges or on $\left\{\begin{matrix}\text{iron}\\ \text{wood}\end{matrix}\right\}$ posts.

107. Switch Protection for Non-Interlocked Switches.

Circuit controllers for non-interlocked switches shall have two independent shunt connections to the track circuit of each track made dangerous by the opening of switch. Switch circuit controllers shall be located on the same side of switch as the normally closed point and connected thereto, and shall be arranged to shunt track circuits when point is open one-quarter (¼) in. or more.

108. Connections.

Track batteries and relays shall be connected to the rails by single conductor $\left\{\begin{matrix}\text{No. 8}\\ \text{No. 10}\end{matrix}\right\}$ B. & S. gage, rubber covered, soft drawn copper wire. Fouling shunt connections and switch box shunt connections shall be made with two single conductor $\left\{\begin{matrix}\text{No. 8}\\ \text{No. 10}\end{matrix}\right\}$ B. & S. gage, rubber covered, soft drawn copper wire.

Rubber covered stranded wire of............B. & S. gage shall be used from trunking to track batteries when track batteries are in chutes.

NOTE.—A minimum gage of No. 12 B. & S. is recommended for such wire.

PAINTING.

110. General.

All materials shall be pure and the quality of paint shall be such as will permit of the application herein specified.

111. Cleaning.

Surfaces covered with rust, grease, dirt or other foreign substances, shall be thoroughly cleaned by scraping or other suitable method before paint or oil is applied.

112. Mixing.

113. Application.

GENERAL.—Paint shall not be applied to outside surfaces in wet weather, nor shall any surface be painted until it is cleaned and dried, nor until previous coating has thoroughly dried.

Pigment finishing coats shall be of sufficient body to form an opaque coating.

Finishing coats shall not be applied sooner than forty-eight (48) hours after the previous coating has been applied.

113. Application—Continued.

Paints mixed on the ground shall be applied within three (3) hours after the pigment and oil are mixed.

All priming coats shall be applied as soon as is consistent with the progress of the work.

All second coatings shall be applied in sufficient time for the third coat to be applied and dry when the plant is completed.

Iron Work.—All iron work, except detector bars and finished parts of machine, shall be given one priming of red lead and raw linseed oil and two (2) finishing coats.

The following specific finishing coats shall be used:

	Kind of Paint.	Color
Signal bridges and brackets..................	....	....
Signal masts	....	....
Switch mechanisms and connections..........	....	....

Wood Work.—Exposed wood work shall be given one priming coat and finishing coats as follows:

	Kind Paint.	Color.	Number Coats.
Home signal blades................	....	....	....
Dwarf signal blades................	....	....	... .
Distant signal blades..............	....	....	....
Trunking, junction boxes, etc......	....	....	....

114. Buildings.

All towers or other buildings in connection with the interlocking plant, if built of wood, shall receive one priming coat and two finishing coats as specified below.

The priming coat shall consist of.........., and, when thoroughly dry, two coats of pure lead and oil, in the following tints, shall be applied:

....

....

....

Prepared paints manufactured by..............................

....

....

will be accepted.

120. Special.

SUPPLEMENTARY SPECIFICATIONS FOR DRAWBRIDGES.

130. Locking.

At least one lever of the interlocking machine, called the bridge lock lever, shall be assigned for the purpose of locking the bridge. The bridge lock lever, when reversed, shall be arranged to lock the bridge in the closed position and to prevent the application of power for the purpose of withdrawing the bridge latch or opening the bridge.

The bridge lock lever, when normal, shall be arranged to lock all

130. Locking—Continued.

levers used for bridge protection in the proper position to protect the bridge, and also to cut off power from all control wires leading to such functions.

A separate locking arrangement shall be provided for each of the following purposes:

(a) To insure that the bridge is in proper alinement.

(b) To insure that all bridge surfacing devices are in their proper position.

(c) To lock all rails in proper position for train movement.

The Purchaser will supply complete information, including detail drawings, of bridge locking apparatus to be controlled by the interlocking machine.

NOTE.—It is recommended as a more desirable method of operation that the rails at the end of the draw and on the shore next to the draw be fixed in position and have the necessary locks, and that lifting rails be not used.

These Specifications for Electric Interlocking were adopted by the Railway Signal Association, and your Committee No. X recommends their adoption by this Association and the printing of these specifications in the Manual.

SUBJECT NO. 3, RUBBER-COVERED WIRE SPECIFICATIONS.

The report of Special Committee on rubber-covered wire and cable of the Railway Signal Association follows:

The Committee has not consulted with rubber manufacturers who do not make insulation for wire, because it did not feel that anything was to be gained by so doing.

The Sub-Committee appointed to consult with the Institute of Electrical Engineers reports that up to the time of filing of this report the Institute of Electrical Engineers have taken no final official action toward the adoption of specifications for rubber-covered wires and cables.

The following data from the report of the Sub-Committee on the effect of impurities in copper will be found below:

THE EFFECT OF IMPURITIES IN COPPER FOR USE AS ELECTRICAL CONDUCTORS.

The presence of any foreign element in copper manifests itself by its effect on the conductivity, malleability, ductility, and tensile strength of the wire.

The conductivity is invariably reduced whenever the slightest trace of anything but pure copper is in the wire, and a certain test for the presence of any impurity is an increase in its electrical resistance over that of pure copper, due to the presence of the foreign body.

These impurities may consist of other metals, or, which is more common, a form of copper oxide which is apparently produced and

dissolved in the copper under certain conditions when in a molten state, as it is not produced by heating to a temperature below the melting point of copper.

Modern processes of manufacture can, however, eliminate practically all impurities, and in fact, the ordinary commercial grades of copper wire made of electrolytic wire bars are so nearly pure copper that the wire generally has a conductivity nearly equal to the supposedly pure copper used by Dr. Matthiessen in his determination of the standard for electrical resistance of copper.

In view of the above facts it is respectfully suggested that the requirements of the specifications in reference to electrical conductivity be unchanged.

Attached is a table showing the effect of one-tenth of one per cent. of various impurities in copper wire.

This table was deduced from a table showing the results of a test by J. O. Mouchel of Paris. He succeeded in producing a sample of pure copper wire which had a conductivity of 104.69 per cent. of Dr. Matthiessen's standard. Assuming this sample to have been pure copper, and using it as a standard, or 100 per cent. conductivity, we have the following results:

EFFECT OF ONE-TENTH PER CENT. ADMIXTURE OF VARIOUS SUBSTANCES WITH COPPER.

Alloying Material.	Conductivity Compared to Soft Copper, 100.	Elongation Per Cent.	Tensile Strength in Pounds Per Square Inch.
Lead	99.38	36.20	27,165
Molybdenum	98.65	33.50	31,163
Cobalt	98.18	38.15	29,342
Silver	98.01	4.25	41,295
Sulphur	98.00	37.55	30,608
Gold	97.94	32.45	29,342
Selenium	97.86	30.42	38,758
Thallium	97.83	36.10	30,253
Zinc	97.76	35.32	38,506
Antimony	95.59	30.00	32,801
Tellurium	95.37	1.82	58,841
Platinum	94.80	38.80	28,986
Nickel	93.96	39.00	29,712
Tungsten	92.43	36.35	30,609
Tin	91.99	3.65	46,133
Chromium	90.75	33.55	32,615
Magnesium	90.06	3.75	51,996
Aluminum	86.49	35.20	31,519
Iron	79.68	32.65	31,377
Arsenic	73.89	39.10	30,879
Silicon	64.52	20.65	26,083
Phosphorus	51.86	31.25	33,327

It will be noted that the conductivity is decreased in every case, while the tensile strength is increased, the' tensile strength of pure annealed copper being about 30,000 lbs. per sq. in.

The following properties of copper containing impurities, while interesting, are of little practical value on account of commercial copper being generally free from the various substances named. This table has been compiled by Mr. Joseph W. Marsh of the Standard Underground Cable Company.

IRON.—Does not affect the mechanical properties; .03 of 1 per cent. reduces conductivity by about 4 per cent.

LEAD.—1/3 of 1 per cent. makes copper red-short (i. e. brittle when red hot) and cold-short, and 3/4 of 1 per cent. ruins the copper entirely for ordinary purposes. Its effect upon the conductivity is small, .35 of 1 per cent. reducing it by about 1 per cent.

TIN.—Injures ductility when 1 per cent. is present. When .05 of 1 per cent. is present, it reduces the conductivity by about 4 per cent.

BISMUTH.—.02 of 1 per cent. makes copper red-short, and .05 of 1 per cent. makes it cold-short. Its effect upon conductivity is small, .05 of 1 per cent. reducing it by about 1/4 of 1 per cent.

ARSENIC.—Slightly affects ductility, but when as much as .8 of 1 per cent. is present, the metal can still be drawn into fine wires. It has a very marked effect upon conductivity and .01 of 1 per cent. reduces the conductivity by about 4 per cent.; and .14 of 1 per cent. reduces the conductivity by about 35 per cent.

ANTIMONY.—.5 of 1 per cent. acts like the same percentage of arsenic so far as mechanical properties are concerned; in larger quantities it is more injurious than arsenic. When .035 of 1 per cent. is present it reduces the conductivity by about 4 per cent.

SILICON.—.3 per cent. must be present before toughness and malleability are affected. 6 per cent. makes the copper brittle. .15 of 1 per cent. reduces the conductivity by about 1/2 of 1 per cent.

SULPHUR.—1/4 of 1 per cent. lowers the malleability and 1/2 of 1 per cent. makes it cold-short, but not red-short. .14 of 1 per cent reduces the conductivity by about 1 per cent.

PHOSPHORUS.—.4 of 1 per cent. makes it red-short. The effect of this impurity upon the conductivity is enormous, .01 of 1 per cent. reduces it by about 20 per cent.

PROPERTIES OF COPPER.

Specific gravity	8.98
Weight per cu. in	.321 lbs.
Weight per cu. ft	555.0 lbs.
Weight per mil. ft	.00000303 lbs.
Resistance per cu. in. 60° F. — 15.5° C	.0000006774 ohms.
Resistance per cu. cm. 0.° C	.000001594 ohms.
Resistance per cu. mil. ft. 0.° C	
Soft drawn 0.° C	9.529
Hard drawn 0.° C	9.741

Tensile strength per sq. in.:

Soft drawn	+30,000.0 lbs.
Hard drawn	50,000. to 60,000. lbs.
Coefficient of expansion C. (0.° — 100° C.)	.0000167
Coefficient of expansion F. (0.° — 100° C.)	.0000093
Melting point (mean)	1100° C.
Boiling point	2100° C.

$$\text{Weight per mile} = \frac{(\text{diam. in mills})^2 \text{ lbs.}}{62.5}$$

$$\text{Resistance per mile } 60^\circ \text{ F.} = \frac{54.692}{(\text{diam. in mills})^2 \text{ ohms.}}$$

Resistance at t° C. $= r\,(1 + .00388t)$.

When $r =$ resistance at 0.° C., $t =$ observed temperature.

$$\text{Percentage of Conductivity} = \frac{100r}{r1}$$

When $r =$ resistance of same size wire of same length and temperature as sample whose conductivity is desired; taken from standard tables.

$r_1 =$ resistance of sample wire.

In hardness copper is between iron and platinum.

In ductility copper is between iron and aluminum.

In malleability copper is between silver and tin.

In conductivity copper is between silver and gold.

The superlative degrees being first in each case; i. e. copper is softer than iron and harder than platinum.

Copper is easily dissolved in hot concentrated { sulphuric acid. nitric acid. aqua regia.

Copper is slowly dissolved by { muriatic acid, dilute sulphuric acid.

Copper is readily attacked by compounds containing sulphur and must be protected from its action when used near such substance. A coating of tin is the most common protective measure used.

The Sub-Committee appointed to prepare specifications for copper clad steel wire has made a considerable investigation of this subject and on the basis of their report the Committee voted as follows:

It was found that the only copper-clad steel wire now on the market or considered by the Committee, is the Monnet wire, made by the Duplex Metals Company.

It was the sense of the Committee that in view of the short time that this wire has been in use, no specifications for it should be embodied in the report, nor any figures as to its properties, though it is the Committee's opinion that as the tensile strength of this wire is

greater than that of hard drawn copper, it may be used on signal circuits where conductivity is an inconsiderable factor, and it is believed desirable that the various members of this Association experiment with this wire to determine its properties in actual service. The use of this wire is also suggested for bonding on track circuits.

Various articles on the subject before the Committee have been studied by its members, visits made to factories and various conferences held with manufacturers and others and as a result of its work for the year the Committee desires to reaffirm, with the exception of a few minor details, the specifications for rubber-covered wire and cable as adopted at Washington, with the exception of the insulation resistance table proposed by it at the Milwaukee meeting.

In order that all the data on this subject may be gathered together under one head, we print below the specifications proposed by the Committee.

Attention is called to the following changes from previous reports:

Paragraph 5, Physical Tests of Copper Conductors—A change in the torsion requirements to suit the various sizes of conductors.

Paragraph 8, Tests of Braiding—Correction made to include the weight of tape in making the absorption test.

Paragraph 9, Physical Tests of Rubber Insulation—A $\frac{7}{16}$ in. set instead of a $\frac{3}{8}$ in. set is permitted on account of many excellent compounds not being able to quite meet the requirements of a $\frac{3}{8}$ in. set.

Paragraph 10, Chemical Tests of Rubber Insulation—An ash test has been added, with a minimum of 62 per cent. and a maximum of 68 per cent., the Committee believing that this will aid materially in determining whether or not the proper amount of rubber has been put into the compound.

Paragraph 11, Electrical Tests of Rubber Insulation—It has been found that 100 volts is sufficient potential for the testing battery for insulation resistance and that most manufacturing plants are not equipped with batteries capable of showing 150 volts as per the former specifications.

SPECIFICATIONS FOR RUBBER-INSULATED WIRE.

600 VOLTS OR LESS.

1. Conductors.

Conductors must be of soft-drawn, annealed copper wire having a conductivity of not less than ninety-eight (98) per cent. of that of pure copper, Matthiessen's standard. Each wire forming a conductor must be continuous without splice throughout its length, must be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy uniform coating of tin.

2. Rubber Insulation.

The vulcanized rubber compound shall contain not less than thirty (30) per cent. nor more than thirty-three (33) per cent. by weight

2. Rubber Insulation—Continued.

of fine dry Para rubber which has not previously been used in rubber compound. The gum itself shall not contain more than three and one-half ($3\frac{1}{2}$) per cent. of resinous extract. The remaining seventy (70) per cent. of the compound shall consist of mineral matter only. The insulation must be tough, elastic, adhering strongly to the wire, must be homogeneous in character and placed concentrically about the conductor.

3. Taping and Braiding.

(a) The rubber insulation must be protected with a layer of cotton tape thoroughly filled with a rubber insulating compound, lapped one-half its width and so worked on as to insure a smooth surface.

(b) The outer braid must consist of one layer of closely woven cotton braiding at least one-thirty-second ($\frac{1}{32}$) of an inch thick, saturated with a black, insulating, weatherproof compound which shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200° Fahrenheit.

4. Tests.

The manufacturer must provide at his factory all apparatus and other facilities needed for making the required physical and electrical tests and must provide the Purchaser's representative with all facilities for assuring himself that the thirty (30) per cent. of rubber as above specified is actually put into the compound. The Inspector shall not be privileged to ascertain what mineral ingredients are used in making up the remaining seventy (70) per cent. of the compound. The manufacturer shall give free access to the place of manufacture and opportunity to test at all necessary times. Tests may also be made upon the finished product after delivery, and the wire will be rejected if it fails to meet the requirements of the specifications. The manufacturer must pay freight charges for return of all wire that may be rejected by the Purchaser.

5. Physical Test of Copper Conductors.

Each solid conductor must stand an elongation of twenty-five (25) per cent. of its length in ten (10) in. before breaking. It must be capable of being wrapped six (6) times about its diameter and unwound without showing signs of breakage after this process has been gone through twice. The tension and torsion tests will be made on separate pieces of wire.

TORSION TEST.

No. 2 to No. 6—20 twists in six in.
No. 8 to No. 10—45 twists in six in.
No. 12 and smaller—80 twists in six in.

6. Conductivity Test of Copper.

The conductivity of the copper shall be determined by measuring the resistance of a length of the wire and comparing with Matthiessen's standard of copper resistance.

7. Tests of Tinning.

Samples of the wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 for one minute. They shall then be rinsed in clear water and immersed in a sodium sulphide of specific gravity 1.142 for thirty-two (32) seconds and again washed. This operation must be gone through with four times before the wire becomes clearly blackened.

8. Tests of Braiding.

Six in. sample of wire with carefully paraffined ends shall be submerged in fresh water of a temperature of 70° Fahrenheit for a period of twenty-four hours. The difference in weight of the sample before and after submersion must not be more than ten (10) per cent. of the weight of the sample before submersion less the weight of the copper, vulcanized rubber and tape.

9. Physical Tests of Rubber Insulation.

A sample of the vulcanized rubber insulation not less than four in. in length shall have marks placed upon it two in. apart. The sample shall be stretched until the marks are six in. apart and then at once released. One minute after such release the marks shall not be over two and seven-sixteenth ($2\frac{7}{16}$) in. apart. The sample shall then be stretched until the marks are nine (9) in. apart before breaking and must have a tensile strength of not less than eight hundred (800) lbs. per sq. in.

10. Chemical Tests of Rubber Insulation.

The vulcanized rubber compound shall contain not more than six (6) per cent. by weight of acetone extract and not more than seven-tenths ($\frac{7}{10}$) of one per cent. of free sulphur; a minimum of sixty-two (62) per cent. and a maximum of sixty-eight (68) per cent. of ash.

11. Electrical Tests of Rubber Insulation.

The circular mills cross-section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength for the various sizes of wire shall conform to the following table:

Size B. & S. Gage.	Area in Circular Mills.	Thickness of Insulation.	Test Voltage Alternating Current.
0	105,592	$\frac{1}{8}$ in. wall	10,000
1	83,694	$\frac{1}{8}$ " "	10,000
2	66,373	$\frac{1}{8}$ " "	10,000
4	41,742	$\frac{3}{32}$ " "	9,000
6	26,250	$\frac{3}{32}$ " "	9,000
8	16,509	$\frac{3}{32}$ " "	9,000
9	13,090	$\frac{5}{64}$ " "	7,000
10	10,380	$\frac{5}{64}$ " "	7,000
12	6,530	$\frac{5}{64}$ " "	7,000
14	4,107	$\frac{5}{64}$ " "	7,000
16	2,583	$\frac{1}{16}$ " "	4,000
18	1,624	$\frac{1}{16}$ " "	4,000

11. Electrical Tests of Rubber Insulation—Continued.

INSULATION RESISTANCE, MEGOHMS PER MILE, 60° F. ONE MINUTE ELECTRIFICATION.

	$\frac{3}{64}$	$\frac{2}{32}$	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{4}{32}$	$\frac{5}{32}$	$\frac{6}{32}$	$\frac{7}{32}$	$\frac{8}{32}$
1 solid ...	....	....	700	900	1000	1100	1300	1400	1600	1700
2 solid ...	....	700	800	1000	1100	1200	1400	1600	1700	1900
3 solid ...	....	800	900	1000	1200	1300	1500	1700	1900	2000
4 solid ...	....	800	1000	1100	1300	1400	1600	1800	2000	2100
5 solid ...	....	900	1100	1200	1400	1500	1700	1900	2100	2300
6 solid ...	....	1000	1200	1300	1500	1600	1900	2100	2300	2400
8 solid ...	1000	1200	1400	1600	1700	1900	2100	2400	2600	2800
9 solid ...	1000	1300	1500	1700	1900	2000	2300	2500	2700	2900
10 solid ...	1100	1400	1600	1800	2000	2200	2400	2700	2900	3100
12 solid ...	1300	1600	1900	2100	2300	2400	2700	3000	3200	3400
14 solid ...	1600	1900	2100	2400	2600	2700	3100	3300	3600	3800

The test for insulation resistance must be made upon all wire after at least twelve (12) hours' submersion in water and while still immersed results being corrected to a water temperature of sixty (60) degrees Fahrenheit. Tests must be made before the application of tape, braid or other covering with a well insulated battery and galvanometer, with not less than one hundred (100) volts and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five (5) minutes, using alternating current from a generator and transformer of ample capacity.

SIGNAL CABLES FOR CIRCUITS CARRYING 600 VOLTS OR LESS.

The Committee has gone into the question of signal cables and finds that the conditions under which signal cables are used and the various types of installation where they are required are so varied that any attempt to go into too great detail would be undesirable. The Committee has, however, compiled and has the honor to present herewith the following specifications for signal cables for circuits carrying six hundred volts or less:

Conductors to be used in signal cables shall conform in all respects to the requirements of the following paragraphs of the specifications for rubber-insulated signal wire:

Paragraph 1. Conductors.
Paragraph 2. Rubber Insulation.
Paragraph 4. Tests.
Paragraph 5. Physical Tests of Copper Conductors.
Paragraph 6. Conductivity Tests of Copper.
Paragraph 7. Test of Tinning.
Paragraph 9. Physical Tests of Rubber Insulation.
Paragraph 10. Chemical Tests of Rubber Insulation.

11. Electrical Tests of Rubber Insulation—Continued.

The dielectric strength of the insulation for the various sizes of conductors shall conform to the requirements of paragraph 11 of the specifications for rubber-insulated signal wire.

The insulation resistance for the various sizes and wall thicknesses shall conform to table A, which is the proposed table of insulation resistance amending the present specifications for rubber-insulated signal wire.

For braided cables the absorption tests of braiding will be in accordance with the requirements of paragraph 8 of the specifications for rubber-insulated signal wire.

The circular mills cross-section, thickness of the rubber insulation, measured at the thinnest point, of the various conductors to be employed in signal cables shall be in accordance with the following tables:

TABLE NO. 1.

WIRE FOR AERIAL CABLES.

Size B. & S. Gage.	Area Cir. Mills.	Thickness of Insulation.
6	26,250	$\frac{5}{64}''$ wall
8	16,509	$\frac{5}{64}''$ wall
9	13,090	$\frac{5}{64}''$ wall
10	10,380	$\frac{1}{16}''$ wall
12	6,530	$\frac{1}{16}''$ wall
14	4,107	$\frac{1}{16}''$ wall
16	2,583	$\frac{3}{64}''$ wall
18	1,624	$\frac{3}{64}''$ wall

TABLE NO. 2.

WIRE FOR UNDERGROUND CABLES.

Size B. & S. Gage.	Area Cir. Mills.	Thickness of Insulation.
6	26,250	$\frac{3}{32}''$ wall
8	16,509	$\frac{3}{32}''$ wall
9	13,090	$\frac{5}{64}''$ wall
10	10,380	$\frac{5}{64}''$ wall
12	6,530	$\frac{5}{64}''$ wall
14	4,107	$\frac{5}{64}''$ wall
16	2,583	$\frac{1}{16}''$ wall
18	1,624	$\frac{1}{16}''$ wall

SPECIFICATIONS FOR AERIAL CABLES BRAIDED.

Conductors furnished in cables must conform to Table No. 1 without tape or braided covering, except tracing wire, which may be taped or braided. The core of the cable must be made up cylindrical in form, with one wire in each layer taped or braided for tracer. Each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. All interstices between conductors in each layer to be filled with jute, each layer of cable to be wrapped with one layer of overlapping tape. Tape must be of closely woven cotton, saturated with a permanent moisture-repelling compound which shall not act injuriously on the insulating compound, cotton, tape or braid. Over the taped core shall be wrapped a bedding of jute not less than $\frac{1}{8}$ in. thick, saturated with tar; one layer of overlapping tape laid on in reverse order to winding of jute, and a closely woven braid saturated with a permanent weatherproofing compound which is not soluble in water.

Cables of more than three and less than seven conductors must be made up with a jute or sisal center.

UNDERGROUND CABLES BRAIDED.

Conductors furnished in cables must conform to Table No. 2, each conductor to be taped or braided, tracing wire to be marked in such

11. Electrical Tests of Rubber Insulation—Continued.

a manner as to be readily identified. The core of cable must be made up cylindrical in form, with one wire in each layer marked for tracer; each layer of core must have a spiral lay, each consecutive layer being spiraled in reverse direction from the preceding one. Cables of more than three and less than seven conductors must be laid up with a jute or sisal center, each layer of cable to be wrapped with one layer of overlapping tape. Tape must be of closely woven cotton, saturated with a permanent moisture-repelling compound and which shall not act injuriously on the insulating compound, cotton, tape or braid.

The taped core shall be covered with a closely woven braid saturated with a permanent weatherproofing compound which is not soluble in water.

LEAD ENCASED CABLES FOR AERIAL USE.

Cables to be constructed under specifications for aerial cables, except that the outside wraps of jute and braid are omitted and the cable protected by a lead sheath of not less than the thickness indicated below:

Diameter of Taped Cable.	Thickness of Lead
3/4" or smaller	1/16"
Larger than 3/4" and not exceeding 1 5/16"	5/64"
Larger than 1 5/16" and not exceeding 2"	3/32"
Larger than 2"	1/8"

LEAD ENCASED CABLES FOR UNDERGROUND USE.

Cables shall be constructed under specifications for underground cables, excepting that the ouside braid is omitted and the cable protected by lead sheath of not less than the thickness indicated below:

Diameter of Taped Cable.	Thickness of Lead
3/4" or smaller	5/64"
Larger than 3/4" and not exceeding 1 5/16"	3/32"
Larger than 1 5/16" and not exceeding 2"	7/64"
Larger than 2"	1/8"

TAPING OF SIGNAL CABLES.

Width of tape not to exceed twice the square root of the diameter of the core to be taped, tape to lap twenty (20) per cent of its width.

PACKING AND SHIPPING.

Completed cables must be shipped on strong reels thoroughly protected by lagging. Both ends of cable on each reel must be accessible for testing, but protected from injury in transportation. Cables must be plainly tagged inside the lagging and each reel on the outside as specified by Purchaser.

FLEXIBLE WIRES.

The Committee has conferred with the manufacturers in regard to the number and size of conductors used for flexible wires and recommends the following table of sizes and strands, it being understood

11. Electrical Tests of Rubber Insulation—Continued.

that the insulating compound and other properties of the flexible wires, so far as consistent, shall conform to the specifications for rubber-covered solid conductors.

STRANDING TABLE.

7 Strands.		19 Strands.		37 Strands.		49 Strands.	
Size of Strand. B.& S.G.	Actual C.M.	Size of Strand. B.& S.G.	Actual C.M.	Size of Strand. B.& S.G.	Actual C.M.	Size of Strand. B.& S.G.	Actual C.M.
11	57,638	11	156,446	11	304,658	11	403,466
12	45,710	12	124,070	12	241,610	12	319,970
13	36,246	13	98,382	13	191,586	13	253,722
14	28,749	14	78,033	14	151,959	14	201,243
15	22,799	15	61,833	15	120,509	15	159,593
16	18,081	16	49,077	16	95,571	16	126,567
17	14,336	17	38,912	17	75,776	17	100,352
18	11,368	18	30,856	18	60,088	18	79,596
19	9,016	19	24,472	19	47,656	19	63,112
20	7,154	20	19,418	20	37,814	20	50,078
21	5,671	21	15,392	21	29,974	21	39,695
22	4,498	22	12,209	22	23,776	22	31,487
23	3,566	23	9,680	23	18,851	23	24,965
24	2,828	24	7,676	24	14,948	24	19,796
25	2,243	25	6,088	25	11,855	25	15,700
26	1,779	26	4,828	26	9,402	26	12,451
27	1,411	27	3,829	27	7,456	27	9,874
28	1,119	28	3,036	28	5,913	28	7,830
29	887	29	2,407	29	4,688	29	6,208
30	704	30	1,910	30	3,719	30	4,925
31	558	31	1,514	31	2,949	31	3,905
32	442	32	1,201	32	2,338	32	3,097
33	351	33	952	33	1,855	33	2,456

At the conference between this Committee and that of the Rubber-Covered Wire Engineers' Association on June 19, a memorandum was presented by the latter Committee, which is given below in full. From this memorandum it will be noted that the manufacturers propose a different stranding table, which has been adopted by the Committee and embodied in the specifications, as has the recommendation in regard to taping.

MEMORANDUM OF JUNE 19.

"At a meeting of the Rubber-Covered Wire Engineers' Association specifications for railway signal wire were carefully considered and all the points mentioned in letter of Chairman Ames of the Railway Signal Association Committee to President Morse, dated May 16, were

11. Electrical Tests of Rubber Insulation—Continued.

fully discussed, and it was unanimously agreed to report to the Signal Engineers' Committee our views on the points raised practically as follows:

(1) Voltage tests should not be so high or so prolonged as to impair the voltage-resisting qualities of the insulating compound.

It is possible for an excessive voltage to overstrain the rubber insulation, so altering its physical structure as to weaken it electrically without actually breaking it down, but the tests specified in our 1907 specification are well within the limit of safety.

Under certain conditions a prolonged high voltage may be indirectly detrimental to the rubber compound either by excessive heating from various causes, or by oxidation from the ozone produced by the static discharges, but such causes have no practical significance for the reasonable voltages and duration of tests now proposed.

(2) The mean or maximum value of the test voltage should of course approximate as nearly as possible to the theoretical value for a sine wave. That is, the maximum value should be about 1.4 times that of the mean effective value; otherwise the readings on the commercial instrument would not be a fair indication of the strain to which the insulation had actually been subjected.

With a suitable testing equipment there should be no danger of excessive voltage on this account, especially when it is remembered that the proposed voltage requirements are based on actual experience with apparatus in commercial everyday use.

It may well be assumed that a manufacturer would for his own protection provide a testing outfit of proper design and of sufficiently ample rating as to prevent any undue distortion. Although a spark gap may be employed to indicate the maximum voltage, its use in practice is limited, as it has to be set for some definite voltage or else the two poles made to approach each other gradually, in which latter case it is not always possible to measure the voltage at the instant desired. The spark gap method is also subject to inaccuracies, as the sparking distance for a given voltage would depend upon the size and shape of the points employed, as well as on the atmospheric and other conditions. The spark gap may even be a source of danger due to the possible rises in voltage when it sparks over.

(3) We believe that the voltage test requirements as specified by Rubber-Covered Wire Engineers' specifications of 1907 are about right, and that if they are applied to signal wire, railroads will receive less defective wire than they would if lower voltages were applied.

We believe that the insulation resistance requirements as advocated by the Signal Engineers' Convention at Milwaukee meeting, 1907, are fully as high as they should be.

(4) If an ash test is adopted the requirements should be a minimum of 60 per cent. and a maximum of 70 per cent.

We believe that the Association should adopt a different table for stranding, and we suggest regular lays of strand, i. e., 7, 19 and 37

11. Electrical Tests of Rubber Insulation—Continued.

for concentric stranding, and 49 for rope laid strand. We recommend that the limit of free sulphur be increased to 1 per cent., and that there be no restrictions regarding 70 per cent. compound.

We believe that the specifications for width of tape on conductors and over multiple cables should be changed so that the requirements would be for tape not to exceed in width twice the square root of the diameter of the core to be taped, tape to lap 20 per cent. of its width.

A compound known as Kerite is so entirely different in its nature from all other compounds used for insulating, we have found it impossible to suggest a specification unless all reference to acetone extract, mineral matter, and ash test be left out, that will include it, and at the same time be a satisfactory specification for other compounds, and inasmuch as wires insulated with Kerite have been in use for fifty years, and have proved their merit, we suggest that a special specification be made for them, in which the mechanical and electrical requirements be the same as called for by general specifications."

As a result of the Committee's instructions to give a hearing to Mr. Brixey and his taking up the question of Kerite compound with the Rubber-Covered Wire Engineers' Association, the latter included in their memorandum of June 19 the paragraph next above written, in which the Committee concurs, with the exception that it does not desire to present a separate specification for his compound.

The Committee has had so much new work assigned to it in addition to work left over from previous years, that it has been unable to prepare specifications for submarine cables. It desires to urge the adoption in full at the annual meeting of the specifications for single conductors and cables which it has the honor herewith to present, and feels that it should be continued and instructed to prepare specifications for submarine cables and undertake the investigation of the question of joint inspection of wires and cables manufactured under the proposed specifications, for the reason that it believes that no matter how good the specifications are that may be adopted, they will be valueless in securing to the roads the product desired unless they are enforced by proper inspection and tests, which can undoubtedly be more economically carried on by a joint inspection bureau than by individual roads.

These specifications for rubber-covered wire were adopted by the Railway Signal Association, and your Committee No. X recommends their adoption by this Association, and the printing of these specifications in the Manual.

SUBJECT NO. 4. STANDARD INTERLOCKING AGREEMENT FOR SIGNAL WORK.

Already covered.

SUBJECT NO. 5. COMPREHENSIVE SYSTEM OF UNIFORM SIGNALING SUITABLE FOR GENERAL ADOPTION.

Report of Standing Committee No. I of the Railway Signal Association (all of whose members are members of Committee No. X) is submitted herewith, and your Committee No. X recommends its adoption as a progress report for transmission to the American Railway Association for its information.

In accordance with the instructions of the Executive Committee, the work for the year 1908 has been divided into two sections.

(1) Further development of a method of uniform signaling, which has been considered by the Committee as a whole.

(2) Development of standard designs for signal apparatus, which has been considered by a Sub-Committee, with the following personnel: J. C. Mock, Chairman; F. P. Patenall, C. C. Anthony, J. A. Peabody, Thos. S. Stevens.

Your attention is here invited to the action taken on the report of the Committee on Signaling Practice, submitted to the Association at the annual meeting of 1907 (1908 A. R. E. & M. W. A.), and appearing on pages 321 to 327 inclusive of Vol. 10 of the Proceedings (pages 45-57 inclusive of Vol. 9 A. R. E. & M. W. A.). This report was adopted by the letter-ballot of this Association, returns from which were announced in February, 1908. The same report was submitted to the American Railway Engineering and Maintenance of Way Association by its Signal Committee No. X and was adopted practically without dissent at the annual meeting of March, 1908. The report has also been submitted to the American Railway Association, but up to August 1, 1908, no action has been taken by that body.

While not specifically so instructed, your Committee has assumed, in carrying on its work for this year, that:

(1) The 1907 (1908 A. R. E. & M. W. A.) report contains a list of signal indications which is reasonably complete, and contains the essential and practicable indications.

(2) That the work of the Committee for the year 1908 should be the development of aspects for the several indications.

In view of the action taken at its meetings during the period from 1904 to 1908, and, after a prolonged discussion of signal practice and signal aspects in Pittsburg, December, 1907, your Committee was of the opinion that the best progress in the development of Aspects would be made if this subject was handled by a sub-committee of three members. In accordance with this feeling, a Sub-Committee, consisting of M. H. Hovey, Chairman; Azel Ames, Jr., and Frank Rhea, was appointed and instructed to obtain from each member of the General Committee his

scheme of aspects to represent the indications appearing in the 1907 (1908 A. R. E. & M. W. A.) report, Exhibit No. 1, page 323 of Vol. 10 of the Proceedings (page 47, Vol. 9, A. R. E. & M. W. A.), review the several schemes and submit a report based thereon at the next meeting of the General Committee. This report was submitted at the Buffalo meeting, May, 1908.

In the work of the Sub-Committee on Aspects and the discussion of the same at the Buffalo meeting, it was found desirable to change the arrangement and wording of the indications appearing in Exhibit No. 1 of the 1907 (1908) report above referred to. The Sub-Committee was, therefore, instructed to revise this exhibit, as found necessary, and submit revised diagram, with accompanying aspects, to the General Committee at its Detroit meeting, July, 1908, which has been done.

In addition to the revision of Exhibit 1 by the Sub-Committee, revisions of this exhibit were also submitted by two other members of the Committee. After a very full discussion, Exhibit 102, included in this report, was approved, and adopted by the Committee. In explanation of this action, your Committee invites your attention to the following:

On page 322, Vol. 10 of the Proceedings (page 46, Vol. 9, A. R. E. & M. W. A.), this conclusion, taken from the 1907 (1908) report, appears: "It is, therefore, the conclusion of the Committee that, in a system of signaling, the aspects should *primarily* serve to indicate *what is required of the engineman in the control of his train,* and *secondarily* should provide for the giving of *certain additional useful information,* limited by the reasonable practicability of displaying the necessary aspects and the added burden upon the engineman's memory that will result from the use of many aspects."

In addition to the above conclusion, it should be held in mind that the basis of the proposed uniform system of signaling included in the 1907 (1908) report, is *the control of the train by the engineman.*

Upon a close analysis, it was found that Exhibit No. 1 had not been developed strictly in accordance with the basis and conclusions immediately preceding, but on the other hand, that they had been departed from materially. This is especially the case with the wording of the indications. Stating this criticism in another way: The *basis* of the proposed system had been disregarded to a certain extent, in grouping and wording the indications.

Exhibit No. 102 will be found to agree with the basis and conclusions of the 1907 (1908) report. The immediate work of this Committee is then to provide logical, practicable and consistent aspects for the indications of this exhibit. Your Committee has been able to reach a decision as to the aspects for the *primary* indications, and submits them herewith, in Exhibit No. 104, for your information.

Your Committee has not been able to decide upon the aspects for the *secondary* indications, but has this matter now under consideration with the expectation of final results for report to the Association at the 1909 (1910) annual meeting.

At the Detroit meeting four different series of aspects for these indications were presented by as many members, but your Committee was not ready to accept any one of the four. It is the Committee's plan to compare the four series, and any further that may be presented, very carefully, and invite full discussion by all members before conclusions are attempted. A Sub-Committee, composed of Messrs. Stevens, Rhea and Mock, has been appointed to develop and present a consistent series of aspects for the *secondary* indications at the next meeting of the Committee.

Your Committee has been handicapped to a considerable extent in its work by the very unfortunate illness of the Chairman, and desires that, except as requested above, this report be accepted as a progress report only; also that the Executive Committee issue instructions to the effect that the work now in hand be continued during the year 1909.

The discussion which took place at the Signal Association Annual Meeting, held in Washington on October 13, 14 and 15, 1908, developed the fact that another scheme of aspects is possible, which should be considered before the final report on aspects is made. For the information of the members, a description of this scheme, with illustrations of the proposed aspects, is appended.

STANDARD DESIGNS AND SPECIFICATIONS FOR MATERIAL.

To the Members of the Railway Signal Association:

On December 13, 1907, President Rudd advised the Chairman that the work of this Committee was to handle the subject of Standard Materials and Designs. Upon receipt of these instructions there was addressed to all the prominent signal companies in the United States an invitation to name a representative with whom the Committee could correspond and who would be thoroughly familiar with the difficulties the manufacturers were experiencing because of the many various designs and variations in specifications that, to all intents and purposes, might better be reduced to one or a few. Your Committee realized that it was necessary to work closely with the manufacturers if permanent results were to be obtained. The manufacturers endorsed this view and named the following representatives:

American Railway Signal Co., Mr. H. M. Abernethy.
Continental Signal Co., Mr. Geo. H. Paine.
Federal Signal Co., Mr. W. W. Laverack.
General Electric Co., Mr. F. B. Corey.
General Railway Signal Co., Mr. M. Wuerpel, Jr.
Hall Signal Co., Mr. W. H. Lane.
Union Switch and Signal Co., Mr. W. E. Foster.

On request of Mr. Paine, he was relieved as representative, and Mr. W. A. D. Short substituted. In June Mr. Ellis resigned as active member of the Committee, becoming representative member for the Federal Signal Company, Mr. Thos. S. Stevens being appointed to succeed Mr. Ellis.

EXHIBIT No. 102 — Accompanying Report of The Committee on Signaling Practice to The Railway Signal Association. Annual Meeting October 1908.

PRIMARY SYSTEM.

BASIC DIAGRAM.

- Control.
  - Immediate Control
    - Stop
    - Proceed
      - Continue
      - Resume normal speed.
      - Proceed at normal speed
      - Proceed at limited speed.
      - Proceed at low speed.
  - Future Control
    - A-Prepare to stop at next signal.
    - B-Prepare to pass next signal at normal speed.
    - C-Prepare to pass next signal at limited speed.
    - D-Prepare to pass next signal at low speed.

INDICATIONS.

Stop.
1. Stop until authorized to proceed.
2. Stop and proceed.
3. Stop and investigate.

Proceed
4. Continue.
5. Resume normal speed.
6. Proceed at normal speed
7. Proceed at normal speed—prepare to stop at next signal ---- = 6+A
8. Proceed at normal speed—prepare to pass next signal at normal speed. ---- = 6+B
9. Proceed at normal speed—prepare to pass next signal at limited speed -- = 6+C
10. Proceed at limited speed.
11. Proceed at limited speed—prepare to stop at next signal -- = 10+A
12. Proceed at limited speed—prepare to pass next signal at normal speed -- = 10+B
13. Proceed at low speed
14. Proceed at low speed—prepare to stop.

Indications eliminated as unnecessary.
- 6+D
- 10+C
- 10+D
- 13+B
- 13+C
- 13+D

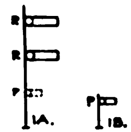
SECONDARY SYSTEM.

INDICATIONS.

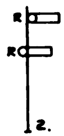
15. There are orders for you. (31)
16. There are orders for you (19)
17. Take siding here
18. Take siding at next station.
19. Proceed - block occupied
20. Stop for passengers
21. There are no passengers for you.

EXHIBIT NO. 104. ACCOMPANYING REPORT OF THE COMMITTEE ON SIGNALING PRACTICE TO THE RAILWAY SIGNAL ASSOCIATION. ANNUAL MEETING, OCTOBER, 1908.

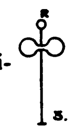
1. Stop until authorized to proceed.



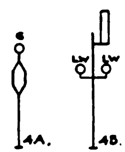
2. Stop and proceed.



3. Stop and investigate.

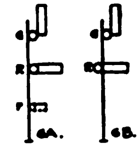


4. Continue.

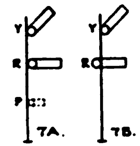


5. Resume normal speed.

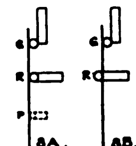
6. Proceed at normal speed.



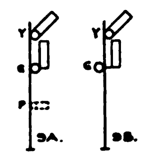
7. Proceed at normal speed—prepare to stop at next signal.



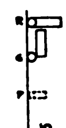
8. Proceed at normal speed—prepare to pass next signal at normal speed.



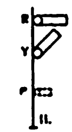
9. Proceed at normal speed—prepare to pass next signal at limited speed.



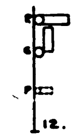
10. Proceed at limited speed.



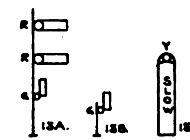
11. Proceed at limited speed—prepare to stop at next signal.



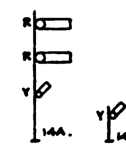
12. Proceed at limited speed—prepare to pass next signal at normal speed.



13. Proceed at low speed.



14. Proceed at low speed—prepare to stop.



The Railway Signal Association, I think, is fortunate in securing the co-operation of these able representatives to assist your Committee in the establishment of standard materials and designs.

PROGRESS.

At the first meeting your Committee submitted the following list of apparatus and materials to the representatives of the signal companies as a beginning and as representing items, if not first in importance, certainly among those first needing standardization:

(1) Crank and crankstand.
(2) Compensator and compensator stand.
(3) One-inch pipe and pipe coupling.
(4) Straight signal poles (steel pipe).
(5) Plain and screw jaws.
(6) Upper quadrant semaphore castings.

Your Committee asked the glass manufacturers if a standard scale could not be adopted whereby the same marking for the same photometric values for lenses and roundels could be used.

Your Committee also discussed the need of specifications for testing of wood fiber, and Mr. Ellis was assigned this subject.

Your Committee has pursued this program during the meetings and also during the time they could devote to the subjects between meetings, with the following results which we hereby submit for your consideration:

MATERIALS SPECIFICATIONS.

SPECIFICATION FOR ONE-INCH PIPE AND COUPLING.

Pipe.

1. Pipe must be of soft steel, straight, tough and uniform in quality; free from cinder pockets, blisters, burns and other injurious flaws. Must be hot galvanized inside and outside, unwiped.

2. The tensile strength, limit of elasticity and ductility shall be determined from a test piece cut from finished pipe.

3. The pipe shall have a tensile strength of not less than 52,000 lbs. per sq. in., and an elastic limit of not less than 30,000 lbs. per sq. in., and an elongation of not less than 18 per cent. in a measured length of eight (8) in. All pipe must stand a test of 600 lbs. per sq. in. internal hydrostatic pressure without leak.

A piece of pipe one (1) ft. long will be selected at random and be subjected to a flattening test by hammering the piece until the opposite sides are within twice the thickness of the wall from each other; the piece shall show no cracks in the steel except at the weld.

4. The weight of one (1) ft. of one-inch pipe before galvanizing should be 1.71 lbs., and in no case will pipe be accepted weighing less than 1.63 lbs. per ft., weight of coupling not included.

5. The outside diameter of pipe must conform to Briggs's Standard. Any pipe enough less than 1.31 in. in diameter to result in flat thread will be rejected.

Pipe—Continued.

6. The manufacturer shall furnish all necessary facilities for making tests and the tests shall be made at the mill.

7. Inside diameter of all pipe must be large enough to receive a hardening steel plug of 63/64 in. diameter for a length of six (6) in.

(8) Not more than one per cent. of pipe less than fifteen (15) ft. long will be accepted, lengths of seventeen (17) ft. and over preferred.

9. The ends of pipe must be cut square and one end drilled for two ¼ in. rivets on one end only; first rivet hole shall be drilled 2 in. from the end and the second 2 in. from this and at right angles to it.

10. Each length of pipe shall have a thread 1⅛ in. long, ⅜ in. total taper per foot, "V" threads slightly rounded top and bottom 11½ to the inch. The threaded portion of the pipe shall be of such diameter as to admit the coupling to be screwed on five turns by hand, with a permissible variation of one turn either way.

Couplings.

Pipe couplings must be galvanized and must be 2¼ in. long and 1¾ in. outside diameter, of wrought iron, free from defects, faced at ends, tapped straight through, pitch diameter of thread to be such as to fit pipe as per Sec. 10 above.

Plugs.

Plugs must be merchant bar steel, 10 in. long, 31/32 in. in diameter, drilled for four ¼ in. rivets with drill .256; spacing to be 1 in., 2 in., 4 in., 2 in., 1 in.; the outside holes to be in one plane and the inside holes to be in a plane at right angles to the outside holes.

Rivets.

Rivets must be galvanized, must be of soft iron or steel ¼ in. in diameter, 1 11/16 in. long.

Gray Iron Castings.

1. Gray iron castings must be of good sound iron, free from flaws, blow holes, fins, cold shuts or shrinkage cracks. They must conform to dimensions shown on drawings and must not exceed the specified weight, when weight is specified.

2. Castings having any section less than ½ in. thick shall be known as light castings.

Castings in which no section is less than 2 in. thick shall be known as heavy castings.

Medium castings are those not included in the above definitions.

Chemical Properties.

Light Castings—Sulphur not over 0.08 per cent.
Medium Castings—Sulphur not over 0.10 per cent.
Heavy Castings—Sulphur not over 0.12 per cent.

Physical Properties.

TRANSVERSE TEST.—The breaking strength of the arbitration bar under transverse load shall not be under:

Light castings, 2,500 lbs.;

Medium castings, 2,900 lbs.;

Heavy castings, 3,300 lbs.;

With load applied at center and the points of support 12 in. apart.

3. The manufacturer's pattern number must appear on each casting and be so located that it will not wear off or interfere with the fitting of other parts to the casting.

4. Castings will be inspected at the shops of the manufacturer, and those which fail to meet the above requirements will be rejected. Test of test specimens may be made at the place of manufacture, the manufacturer to furnish suitable apparatus to make the test without expense to the purchaser; or these tests may be made at destination if the purchaser so desires, in which case the foundry will furnish two arbitration bars for each melt used in filling the shipment.

A blue print showing the arbitration bar and its mold will be supplied to those filling orders for gray iron castings for the purchaser, upon request.

Malleable Iron Castings.

1. Malleable iron castings must be well rattled, clean and reasonably free from flaws or shrinkage cracks. They must conform to the dimensions specified and must not exceed the specified weight when a weight is given.

2. Manufacturers will submit, for approval, a sample casting from each pattern, when so requested.

3. When shown on the blue print, each casting must have one or more test lugs. The shape, size and number must be as specified, although the location will be left to the option of the manufacturer. The test lugs, when broken off, shall show tough and strong material.

Machinery Steel.

1. All sections must be true to size, free from cracks, flaws and defects of all kinds.

2. When subjected to a tensile test the steel must show: Tensile strength per sq. in., 48,000 to 58,000 lbs. Elongation in 8 in. not less than 25 per cent.

3. Phosphorus not to exceed 0.1 per cent.; sulphur not to exceed 0.065 per cent.

4. When subjected to a bending test, either hot or cold, the steel must bend double over a diameter equal to its own thickness without showing any fracture.

5. The results of the chemical analysis made at the steel works of each melt used to fill the order must be furnished to the purchaser's inspector when requested.

Machinery Steel—Continued.

Mild steel will be inspected and tested at the shops where it is to be used.

If the material fails to meet the requirements of these specifications it will be rejected and returned at the expense of the manufacturer.

Wrought Iron Bars.

1. All sections must be true to size and shape ordered. Round iron must conform to the M. C. B. standard limit gages.

2. Iron must be free from cracks, flaws, unwelded seams and mechanical defects of all kinds, and must be free from steel scrap.

3. Samples taken at random, one test specimen from 50 bars, approximately, must pass the following tensile test:

Tensile strength per sq. in., not below 48,000 lbs.

Elongation in 8 in., not less than 20 per cent.

The fractures must not be more than 15 per cent. crystalline.

4. When subjected to bending test, either hot or cold, the iron must bend through an angle of 180 degrees around a diameter equal to twice the thickness of the bar without crack or fracture. In competent hands the iron must give perfect welds.

5. All iron showing defects in working, rendering it unfit for service, will be rejected and returned to manufacturer at his expense.

6. The iron shall be inspected at the shops where it is to be used and if it fails to meet the requirements of these specifications, it will be rejected and returned at the expense of the manufacturer.

SPECIFICATIONS FOR SIGNAL ROUNDELS, LENSES AND GLASS SLIDES.

GENERAL.

Material.

All glasses must be of clear uniform solid color, containing the highest proportions of lead compatible with durability and securing the required color and must have a specific gravity of not less than 2.75. Chipped or flashed glasses will not be accepted.

Workmanship.

Workmanship shall be of the best, and glasses must be true to size and form, and practically free from bubbles, streaks, and wrinkles.

Color.

Red, green, yellow, blue, purple and lunar white glasses will be purchased.

Wrapping.

Each glass must be wrapped in paper of corresponding color.

Tests.

The manufacturer must test each glass, placing thereon a label showing the photometric value.

The purchaser reserves the right to make repetition of the above test, to insure that only material meeting the requirement is ac-

Tests—Continued.

cepted, and all materials not meeting such requirements will be rejected. All red glasses must be submitted to the sodium test.

Samples.

The manufacturer must submit samples of glasses, showing the extreme limits of colors which it is proposed to furnish. These shall bear labels showing the photometric values, and if approved will be kept in the office of........................... as standards.

Rejected Material.

The purchaser will notify the manufacturer promptly as to rejected material, which will be retained not longer than two weeks from date of notification. If at the end of that time the manufacturer has not advised the purchaser as to disposition, such materials will be returned to the manufacturer at his risk, the manufacturer paying the freight both ways in either case.

ROUNDELS.

Design.

Roundels must be of diameter specified in order, and between .21 in. and .29 in. thick.

Roundels will be subject to spectro-photometric analysis. The following table gives an analysis of roundels of the various colors of medium intensity, the letters indicating lines of the spectrum, and the figures showing percentages of light transmission at the different points. Roundels of medium intensity should transmit light as nearly as possible of this composition, a reasonable variation being allowed for light and dark limits:

	A	a	B	C	D	E	b	F	G	H
Red	60	65	70	72	0	0	0	0	0	0
Green	0	0	0	0	4	27	40	45	25	0
Yellow	0	38	50	43	41	12	9	3	0	0
Blue	0	0	0	0	3	4	6	24	40	46
Purple	0	42	42	0	0	0	0	2	43	42
Lunar White	0	62	49	17	15	25	38	65	74	0

Briefly describing the above photometric values.

Red.

Will be of such quality that all yellow rays of light are absorbed, the spectrum being either red or red and orange. The photometric value shall be, light 130, standard 100, dark 70.

Green.

Will be of the color known as Admiralty green, having a slightly bluish tint. The spectrum shall show very little yellow, being a full green with some blue. The photometric value shall be, light 125. standard 100, dark 75.

Yellow.

Will give a spectrum showing a full yellow band, most of the red and slightly of the green. The photometric value shall be, light 120, standard 100, dark 80.

Blue.

Will give a spectrum having a full blue band, with a narrow band of green. The photometric value shall be, light 125, standard 100, dark 75.

Purple.

Will give a spectrum showing a considerable proportion of both red and blue. The photometric value shall be, light 125, standard 100, dark 75.

Lunar White.

Shall show a maximum of absorption for the yellow. The photometric value shall be, light 120, standard 100, dark 80.

LENSES.

Design.

All lenses must be of the optical pattern, focusing to a plane rather than to a point, and must be of the polyzonal type, with smooth outer face. All parts of the lens must focus to an area not exceeding ⅜ in. in diameter for all lenses up to the 6 in. size, nor exceeding ½ in. in diameter for the larger sizes; must be so designed that the divergence of the projected beam (i. e., spread), with flame 1 in. broad, shall not exceed 1 ft. from the axis in 8 ft. When observed at a distance of 30 or 40 ft., a small flame oil burner being placed in the focus, the whole lens shall be equally illuminated, the "risers" on the inner surface showing only as narrow dark rings.

All lenses 6⅜ in. and over, diameter, must have at least five zones, and the smaller lenses four, and must be corrugated inside.

Color.

Colored corrugated lenses must have the same photometric and spectro-photometric values as roundels of the same color, but allowance will be made for divergences due to irregularities of manufacture.

Focus.

The focus of each lens must be stamped on the outer zone.

GLASS SLIDES.

Material.

The glass must be double thick, and of the same character of material as furnished for lenses and roundels. Thickness of slides shall be not less than .095 in. and not more than .15 in.

Design.

Slides must be cut or pressed to size ordered.

The following is a list of standard drawings:

Wire Adjusting Screw, Dwg. No. 1001.
Pipe Adjusting Screw, Dwg. No. 1002.
Obtuse Angle Crank, Dwg. No. 1003.
Acute Angle Crank, Dwg. No. 1004.

Design—Continued.
Three Arm Crank, Dwg. No. 1005.
Straight Arm Crank, Dwg. No. 1006.
Right Angle Crank, Dwg. No. 1007.
One-Way Crankstand, Dwg. No. 1008.
Two-Way Crankstand, Dwg. No. 1009.
One and Two-Way Crank Pins, Dwg. No. 1010.
One-Way Crankstand Complete, Dwg. No. 1011.
Two-Way Crankstand Complete, Dwg. No. 1012.
One-Way Compensator Base, Dwg. No. 1013.
One-Way Compensator Complete, Dwg. No. 1014.
One-Inch Pipe and Coupling, Dwg. No. 1015.
Straight Solid Jaw (Tang End), Dwg. No. 1016.
Offset Solid Jaw (Tang End), Dwg. No. 1017.
Wide Jaw (Tang End), Dwg. No. 1018.
Slotted Jaw (Tang End), Dwg. No. 1019.
Screw Jaw, Dwg. No. 1020.
Screw Jaw (Tang End), Dwg. No. 1021.
Solid Jaw (Butt End), Dwg. No. 1022.
Lug (Tang End), Dwg. No. 1023.
Straight Adjustable Link, Dwg. No. 1024.
Solid Link, Dwg. No. 1025.
Standard Ladder for Pipe Mast, Dwg. No. 1026.
Top of Ladder, Dwg. No. 1027.
Sides for Ladder Stays, Dwg. No. 1028.
Front and Back Clamps for Ladder Stays, Dwg. No. 1029.
Standard 38 ft. 2 in. Pipe Signal Mast, Dwg. No. 1030.
Standard 31 ft. 8 in. Pipe Signal Mast, Dwg. No. 1031.
Standard 25 ft. 2 in. Pipe Signal Mast, Dwg. No. 1032.
Jaw Pin, Dwg. No. 1033.
Base for 6-in. Signal Mast, Dwg. No. 1034.

All of the above standard designs and specifications were adopted by the Railway Signal Association, and it is recommended that they be adopted by this Association and printed in the Manual.

In conclusion, your Committee would suggest that possibly some of the subjects, other than No. 5, herewith reported on may be such as in the judgment of the Board of Direction should be transmitted to the American Railway Association.

Your Committee would further suggest that during the coming year the Committee's work be the completion of the work now in hand.

Respectfully submitted,

A. H. Rudd (*Director*), Signal Engineer, Pennsylvania Railroad, Philadelphia, Pa., *Chairman*.

L. R. Clausen, Superintendent, Chicago, Milwaukee & St. Paul Railway, Chicago, Ill., *Vice-Chairman*.

Azel Ames, Jr., Signal Engineer, New York Central & Hudson River Railroad, New York, N. Y.

C. C. Anthony, Assistant Signal Engineer, Pennsylvania Railroad, Philadelphia, Pa.

H. S. Balliet, Engineer Maintenance of Way, Grand Central Station and Electric Division, New York Central & Hudson River Railroad, New York, N. Y.

H. S. Cable, General Superintendent, Central District, Chicago, Rock Island & Pacific Railway, Davenport, Ia.

C. A. Christofferson, Signal Engineer, Chicago Great Western Railway, St. Paul, Minn.

G. E. Ellis, Albany, N. Y.

M. H. Hovey, Chicago, Ill.

J. C. Mock, Electrical Engineer, Detroit River Tunnel Company, Detroit, Mich.

F. P. Patenall, Signal Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

J. A. Peabody, Signal Engineer, Chicago & Northwestern Railway, Chicago, Ill.

Frank Rhea, Schenectady, N. Y.

W. B. Scott, Assistant Director of Maintenance and Operation Harriman Lines, Chicago, Ill.

Thos. S. Stevens, Signal Engineer, Santa Fe System, Topeka, Kan.

J. E. Taussig, Terminal Superintendent, Wabash Railroad, St. Louis, Mo.

H. H. Temple, Superintendent, Baltimore & Ohio Railroad, New Castle, Pa.

H. M. Waite, Superintendent, Seaboard Air Line, Birmingham, Ala.

Edwin F. Wendt (*Director*), Assistant Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa.

Committee.

EXPLANATION OF SUGGESTED SERIES OF ASPECTS AS SHOWN IN EXHIBIT NO. 106.

Diagram "A" shows the fundamental principles upon which the series of aspects is based. It will be noted that the upper and lower arms give information leading to the immediate control of a train.

The upper arm gives the following indications:

90 degree position, Normal Speed.

45 degree position, Limited Speed.

0 degrees or horizontal, Stop.

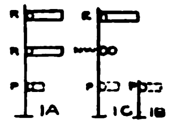
The lower arm is used for slow speed.

The second arm gives information leading to the future control of a train. It is a *TRUE* repeater of the upper arm of the signal in advance.

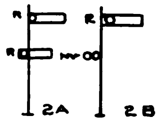
The same indications are used as in Exhibit No. 104. It will be noted in this series of aspects that as the indications become more favorable to the runner, yellow and then green is substituted for red in the order named.

EXHIBIT NO. 106. SUGGESTED SERIES OF ASPECTS WHICH WILL BE GIVEN CONSIDERATION BY COMMITTEE BEFORE MAKING FINAL REPORT.

1. Stop until authorized to proceed.

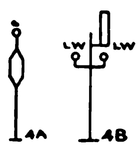


2. Stop and proceed.



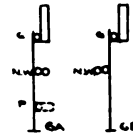
3. Stop and investigate.

4. Continue.

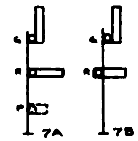


5. Resume normal speed.

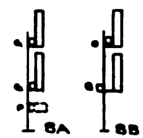
6. Proceed at normal speed.



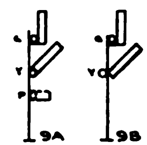
7. Proceed at normal speed—prepare to stop at next signal.



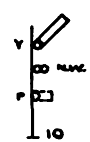
8. Proceed at normal speed—prepare to pass next signal at normal speed.



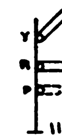
9. Proceed at normal speed—prepare to pass next signal at limited speed.



10. Proceed at limited speed.

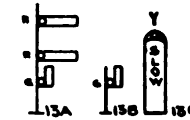


11. Proceed at limited speed—prepare to stop at next signal.



12. Proceed at limited speed—prepare to pass next signal at normal speed.

13. Proceed at slow speed.



14. Proceed at slow speed—prepare to stop.

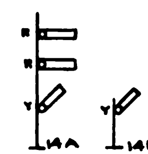
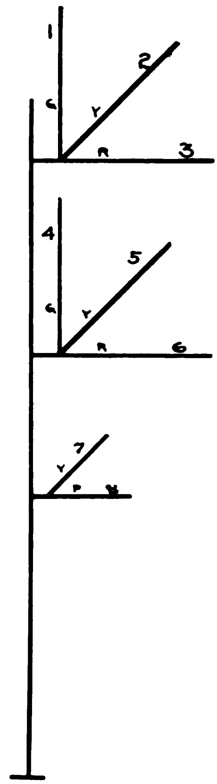
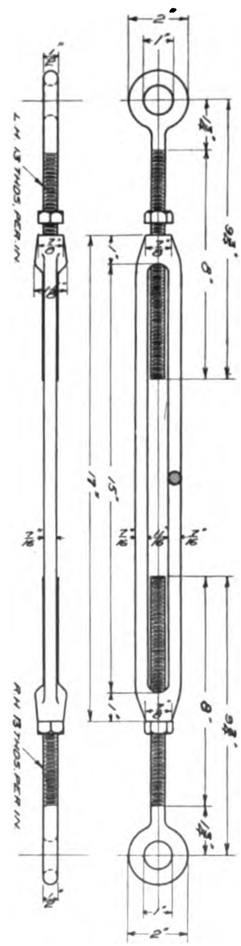


DIAGRAM A. FUNDAMENTAL PRINCIPLES UPON WHICH ARE BASED THE SERIES OF ASPECTS SHOWN ON EXHIBIT NO. 106.



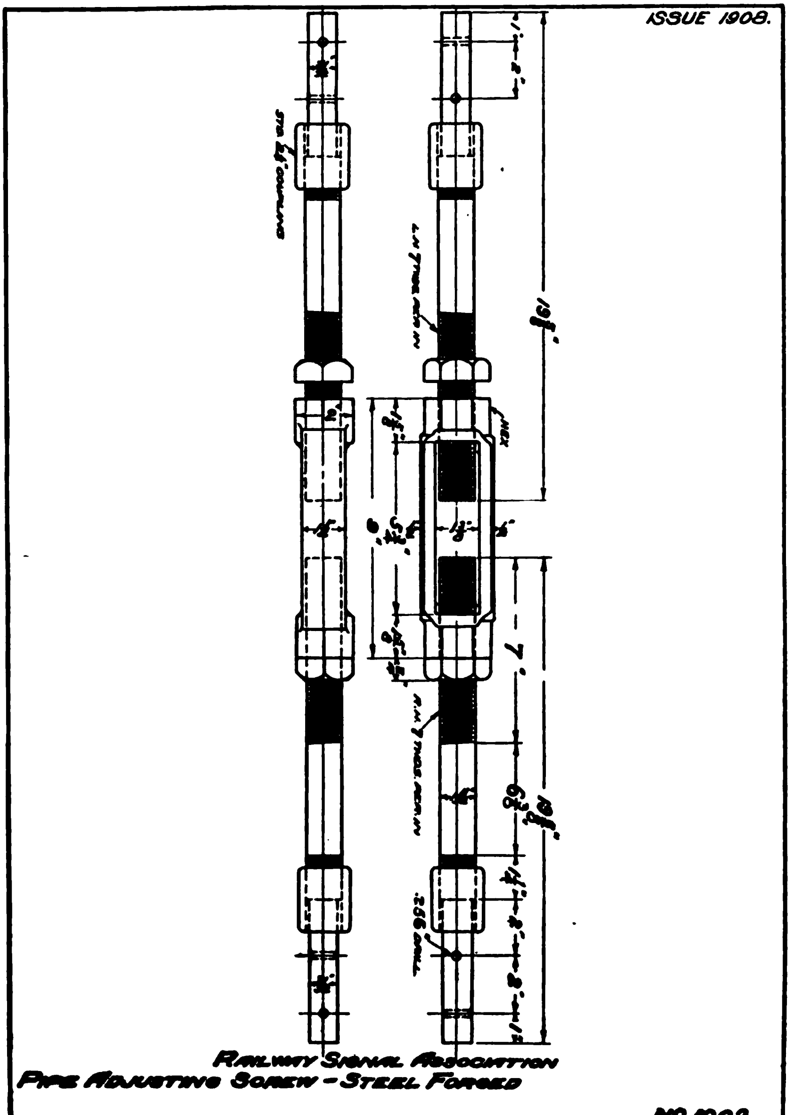
1. Proceed at normal speed.
2. Proceed at limited speed.
3. Stop.
4. Prepare to pass next signal at normal speed.
5. Prepare to pass next signal at limited speed.
6. Prepare to stop at next signal.
7. Proceed at low speed.
8. Of no significance, except to mark presence of a low speed signal.

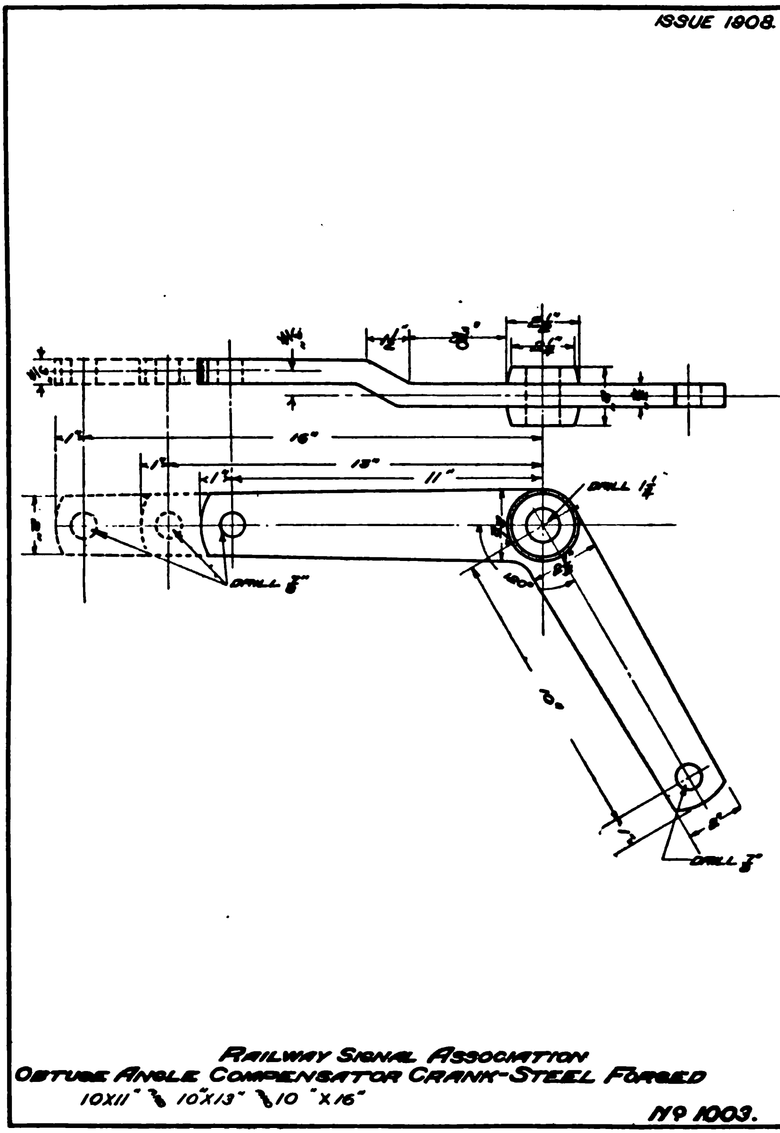
ISSUE 1908.



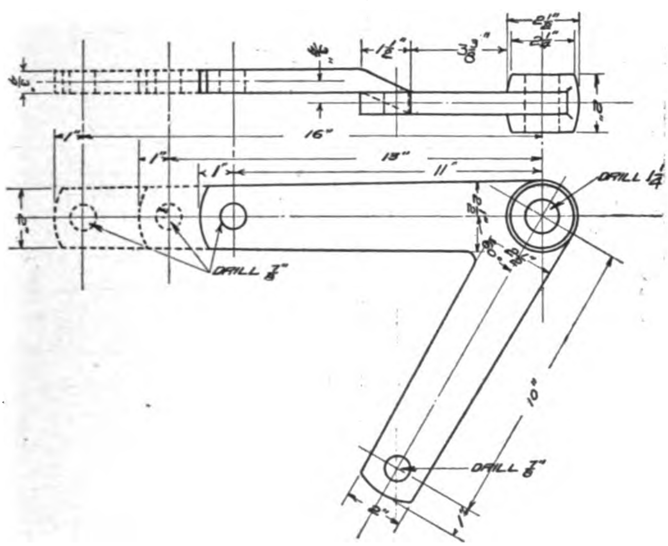
RAILWAY SIGNAL ASSOCIATION
WIRE ADJUSTING SCREW-STEEL FORGED

No. 1001.


ISSUE 1908.
RAILWAY SIGNAL ASSOCIATION
PIPE ADJUSTING SCREW - STEEL FORGED
Nº 1002.


ISSUE 1908.
16"
13"
11"
DRILL 1 1/4"
DRILL 7/8"
DRILL 7/8"
RAILWAY SIGNAL ASSOCIATION
OBTUSE ANGLE COMPENSATOR CRANK-STEEL FORGED
10X11" & 10"X13" & 10"X16"
Nº 1003.

ISSUE 1908

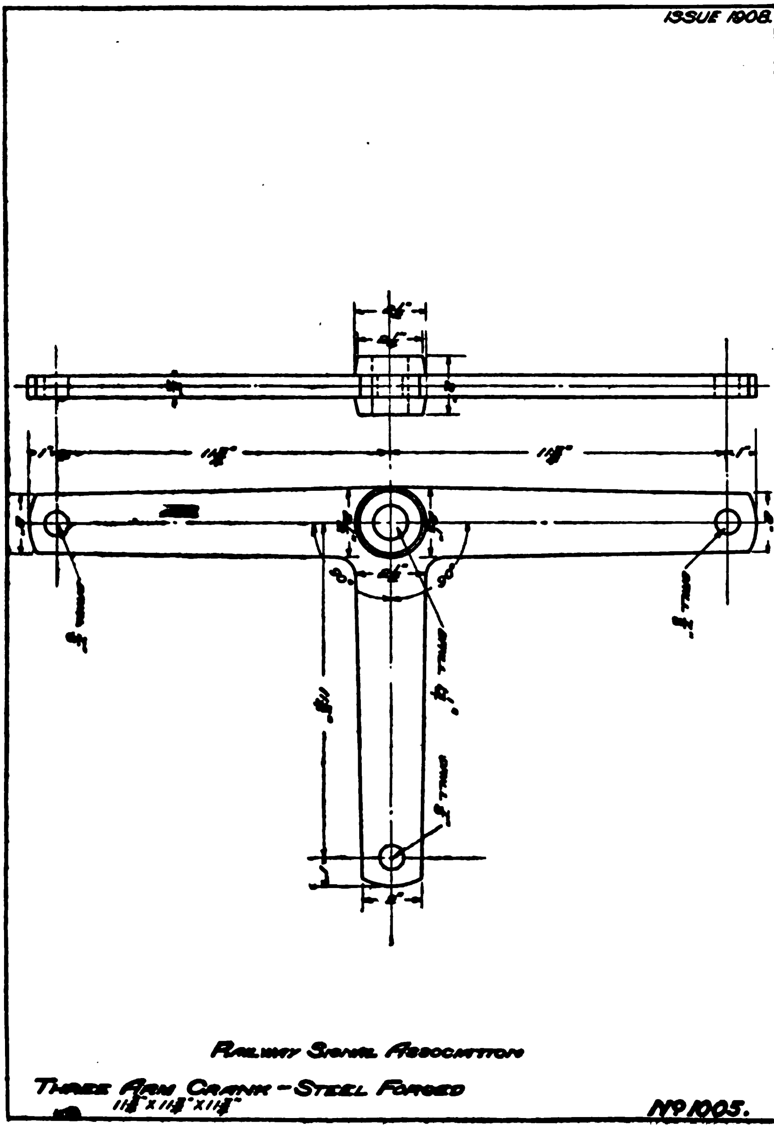


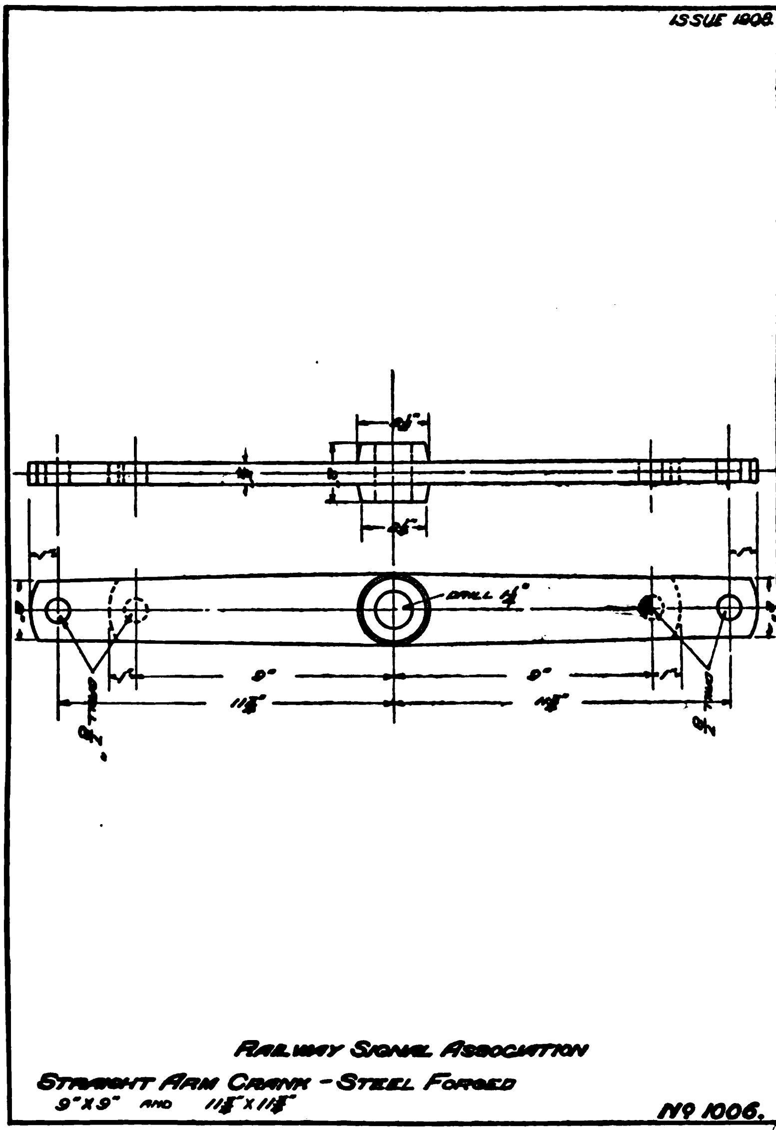
RAILWAY SIGNAL ASSOCIATION

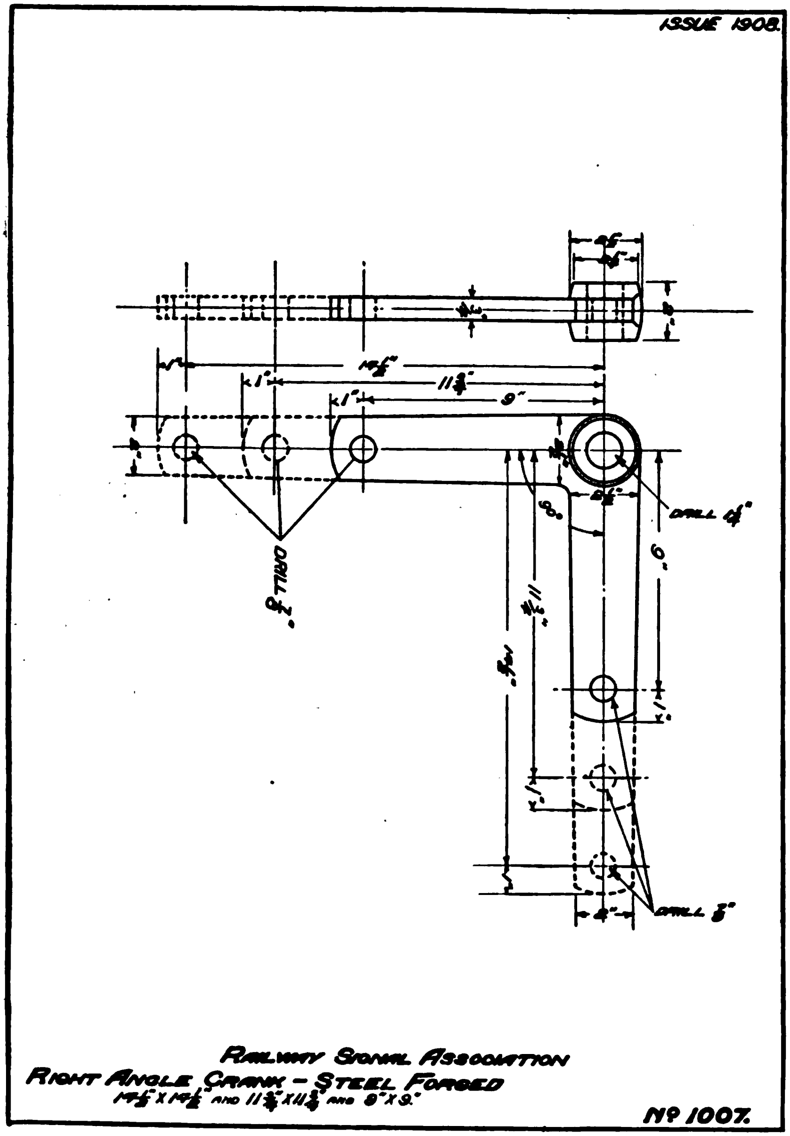
ACUTE ANGLE COMPENSATOR CRANK—STEEL FORGED

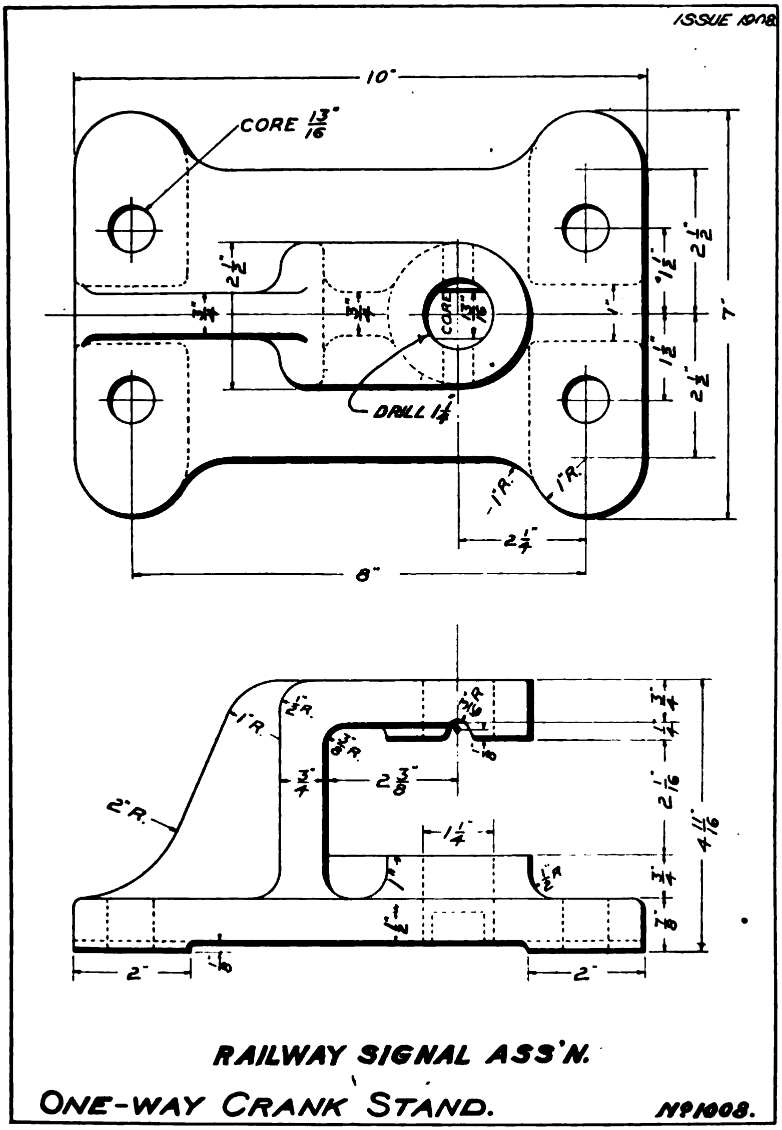
10" X 11" AND 10" X 13" AND 10" X 16"

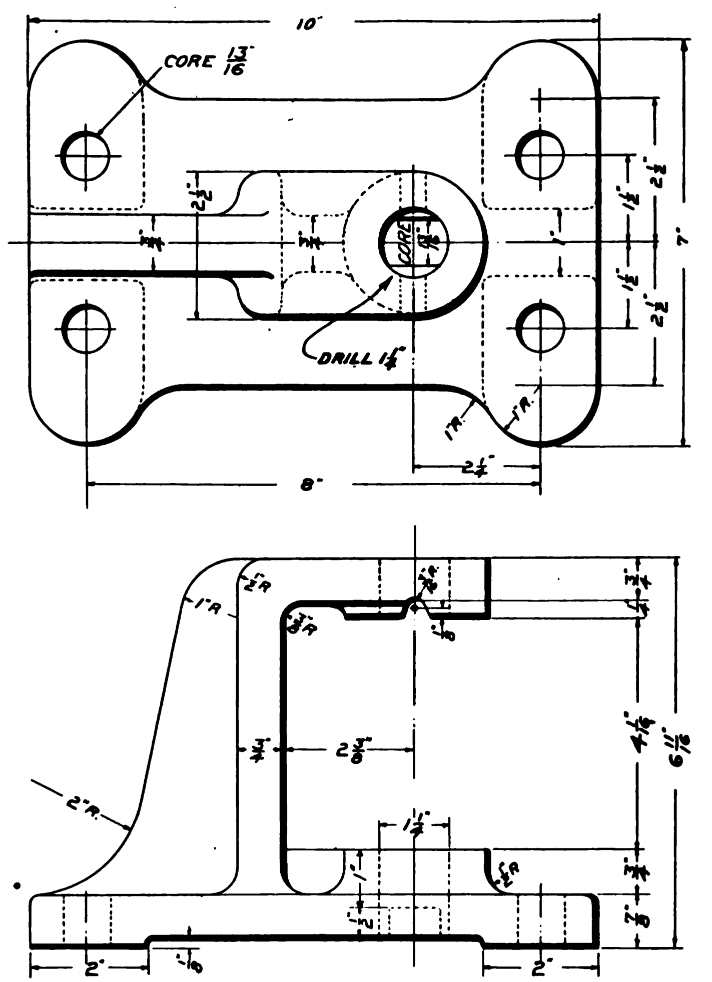
No 1004.


ISSUE 1908.
RAILWAY SIGNAL ASSOCIATION
THREE ARM CRANK – STEEL FORGED
No 1005.


ISSUE 1908
DRILL
9"
9"
RAILWAY SIGNAL ASSOCIATION
STRAIGHT ARM CRANK - STEEL FORGED
9"X9" AND
No 1006.


ISSUE 1908.
DRILL
DRILL
DRILL
RAILWAY SIGNAL ASSOCIATION
RIGHT ANGLE CRANK - STEEL FORGED
No 1007.

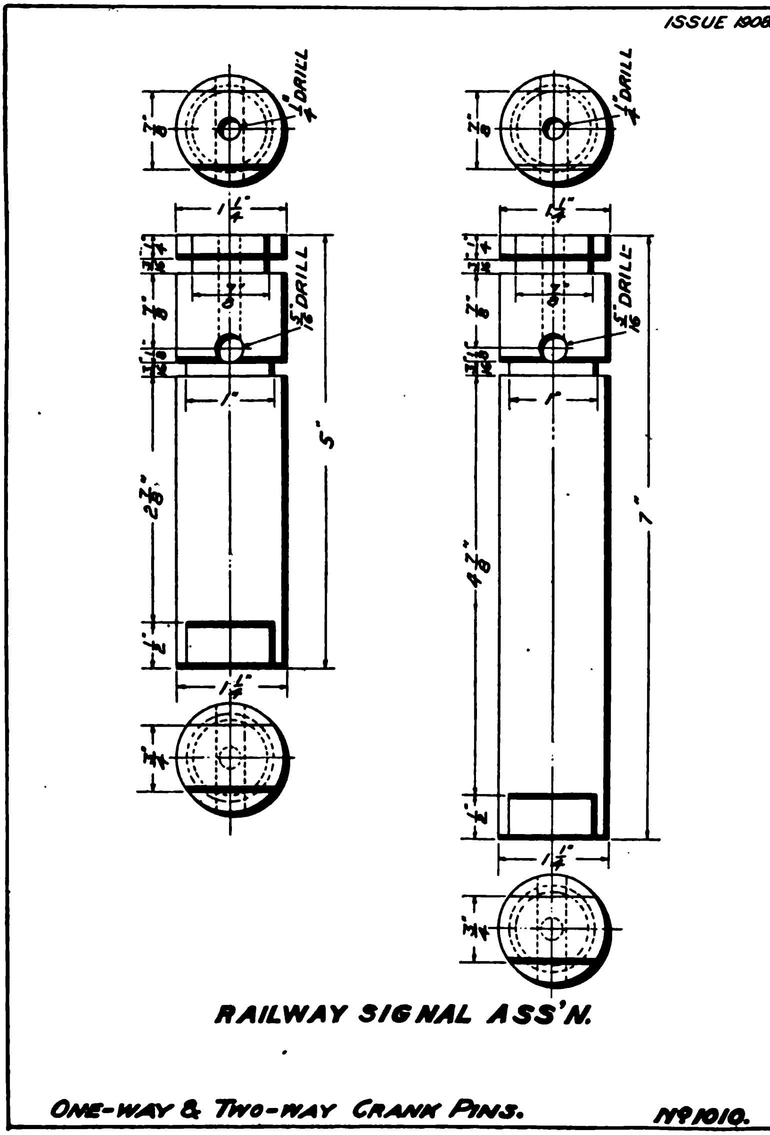

ISSUE 1908
10"
CORE 13/16"
DRILL 1 1/4"
8"
2 1/4"
7"
RAILWAY SIGNAL ASS'N.
ONE-WAY CRANK STAND.
No. 1008.

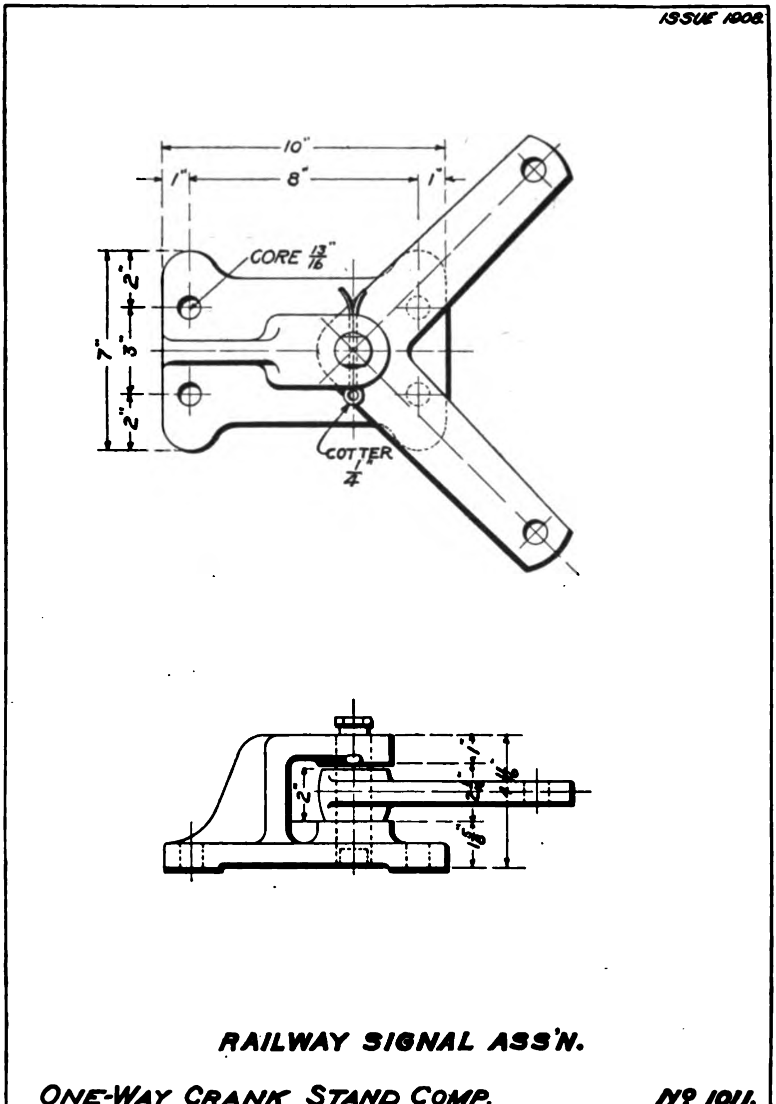


RAILWAY SIGNAL ASS'N.

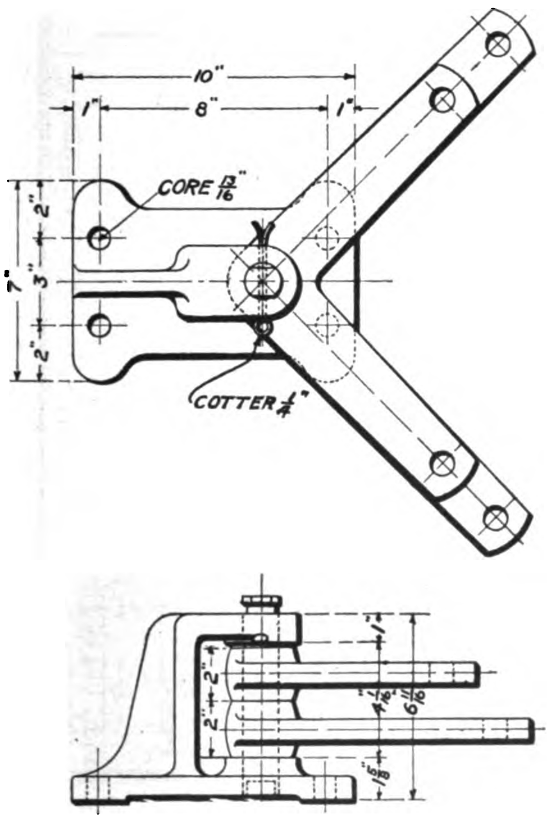
TWO-WAY CRANK STAND.

Nº 1009.


ISSUE 1908.
$\frac{1}{4}$" DRILL
$\frac{7}{8}$"
$1\frac{1}{4}$"
$\frac{5}{16}$" DRILL
1"
5"
$2\frac{7}{8}$"
7"
$4\frac{7}{8}$"
$\frac{3}{4}$"
RAILWAY SIGNAL ASS'N.
ONE-WAY & TWO-WAY CRANK PINS.
Nº 1010.

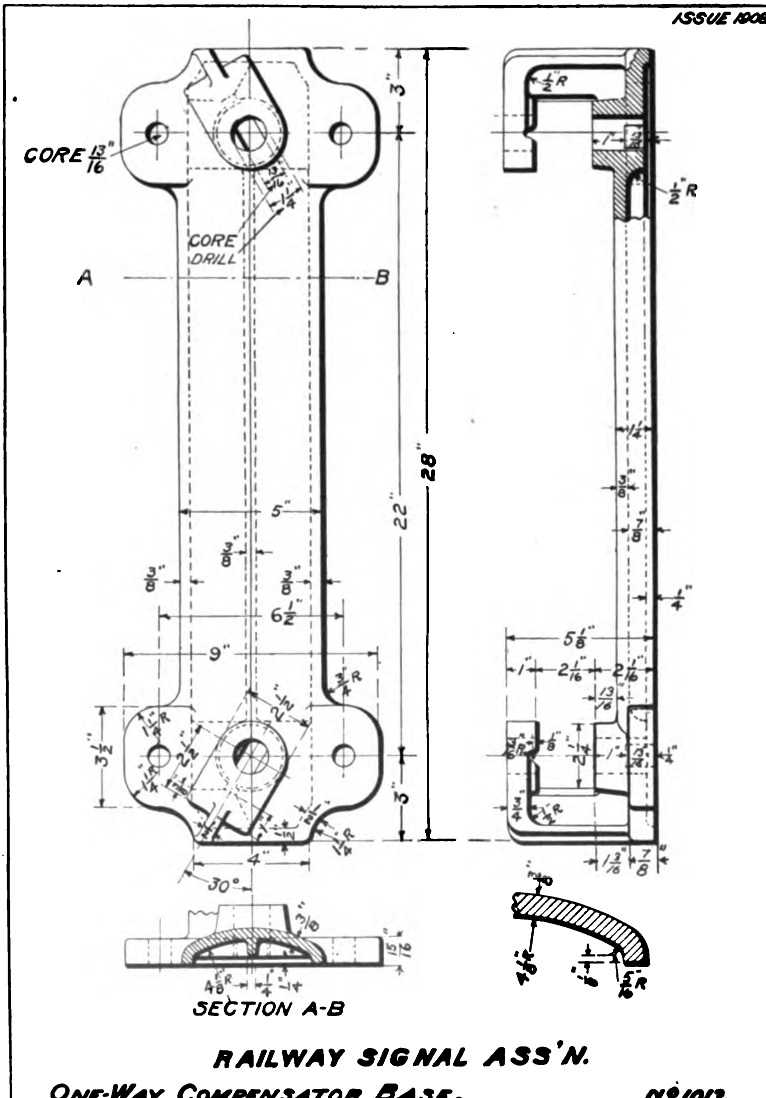

ISSUE 1908.
10"
1"
8"
1"
CORE 13/16"
7"
2"
3"
2"
COTTER 1/4"
2"
RAILWAY SIGNAL ASS'N.
ONE-WAY CRANK STAND COMP.
Nº 1011.

ISSUE 1908.

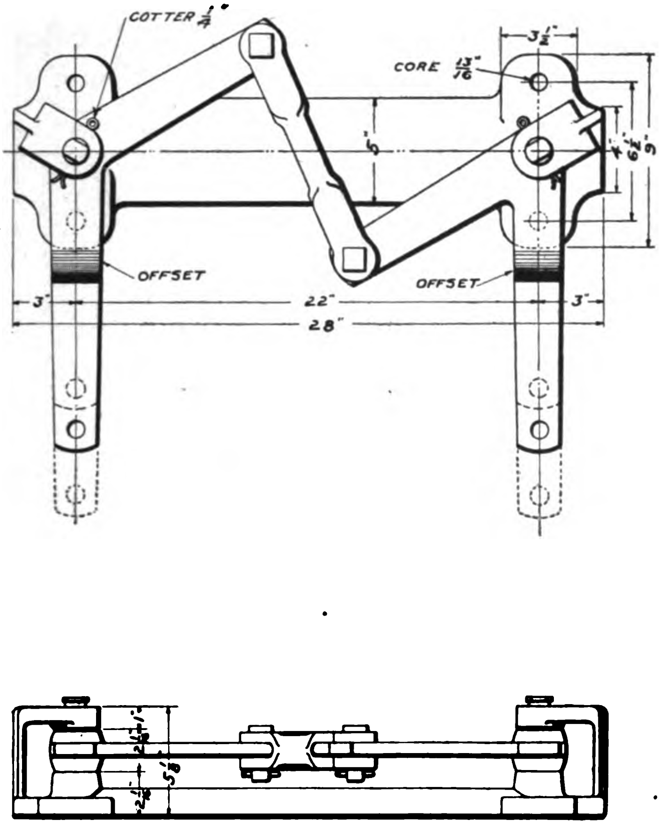


RAILWAY SIGNAL ASS'N.

TWO-WAY CRANK STAND COMP. **Nº 1012.**

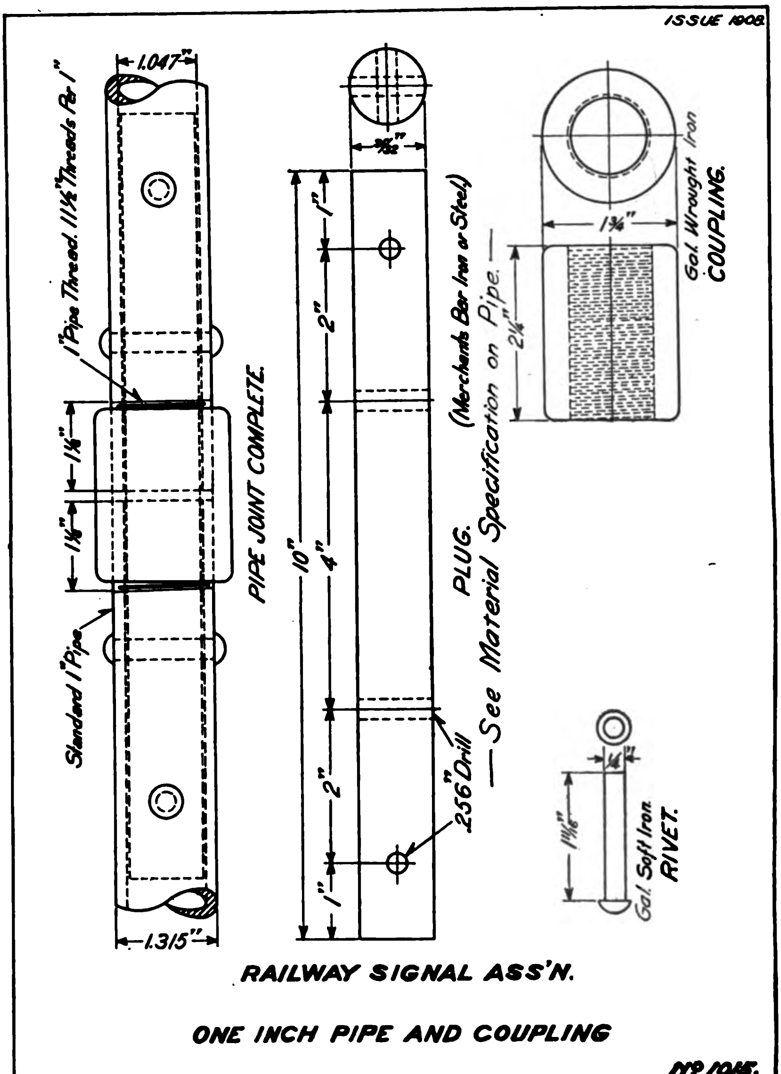

ISSUE 1908.
CORE 13/16"
CORE DRILL
A
B
SECTION A-B
RAILWAY SIGNAL ASS'N.
ONE-WAY COMPENSATOR BASE.
Nº 1013.

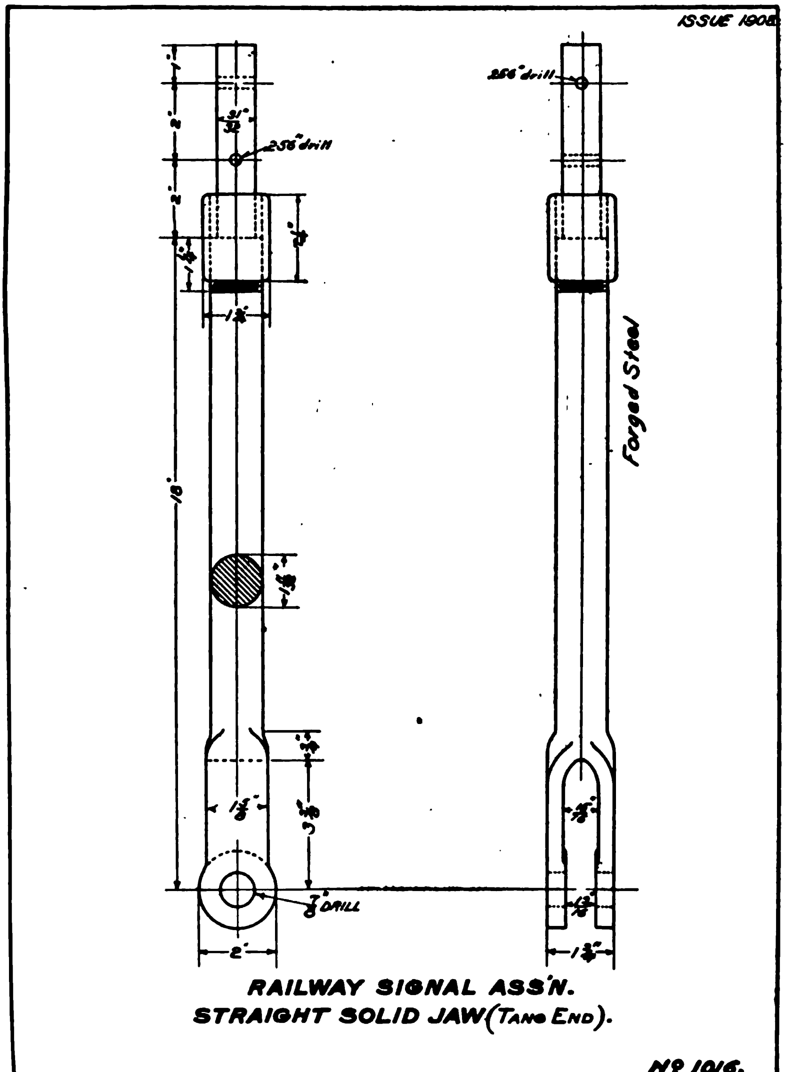
ISSUE 1908.

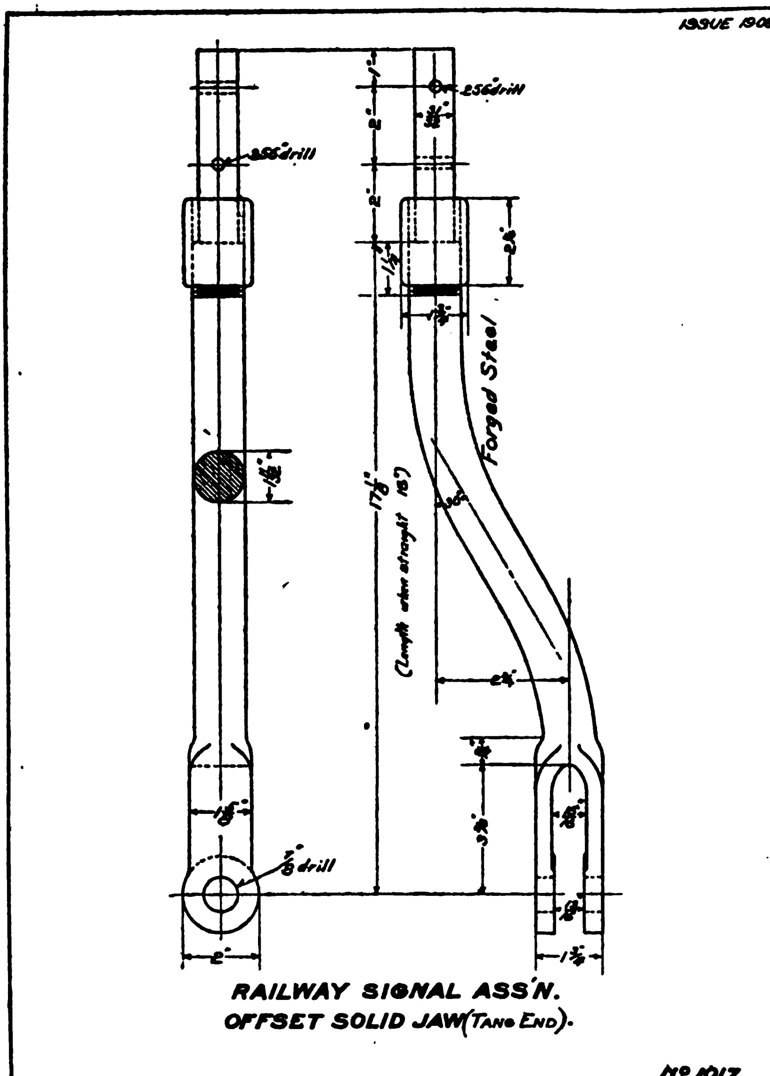


RAILWAY SIGNAL ASS'N.
PIPE COMPENSATOR.

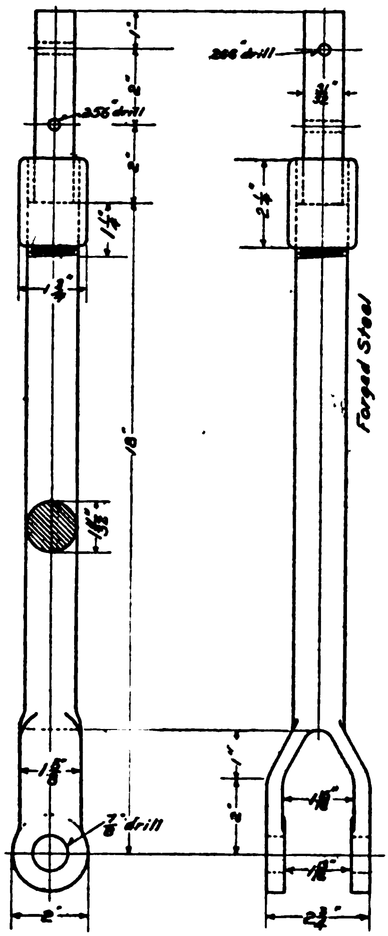
No 1014.


ISSUE 1908
1.047"
1" Pipe Thread. 11½" Threads Per 1"
Standard 1" Pipe
1.315"
PIPE JOINT COMPLETE.
10"
PLUG.
(Merchants Bar Iron or Steel)
.256" Drill
—See Material Specification on Pipe.—
1¾"
2¼"
Gal. Wrought Iron
COUPLING.
Gal. Soft Iron.
RIVET.
RAILWAY SIGNAL ASS'N.
ONE INCH PIPE AND COUPLING
Nº 1015.


ISSUE 1908
.256" drill
.256" drill
Forged Steel
7/8" DRILL
RAILWAY SIGNAL ASS'N.
STRAIGHT SOLID JAW (TANG END).
Nº 1016.

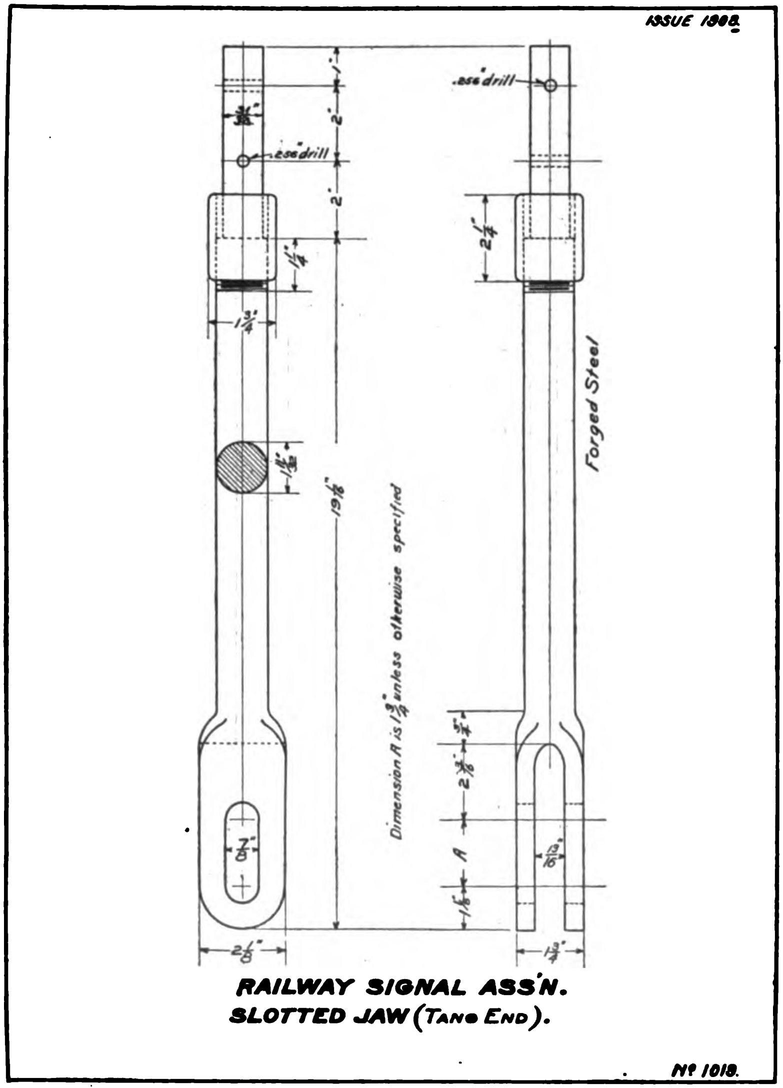

ISSUE 1908
.256" drill
.256" drill
1"
2"
2"
$1\frac{1}{2}$"
$2\frac{1}{8}$"
$1\frac{1}{2}$"
Forged Steel
$17\frac{1}{8}$"
(Length when straight 18")
$2\frac{3}{4}$"
$3\frac{7}{8}$"
$\frac{7}{8}$" drill
2"
$1\frac{3}{4}$"
RAILWAY SIGNAL ASS'N.
OFFSET SOLID JAW (TANG END).
No 1017.

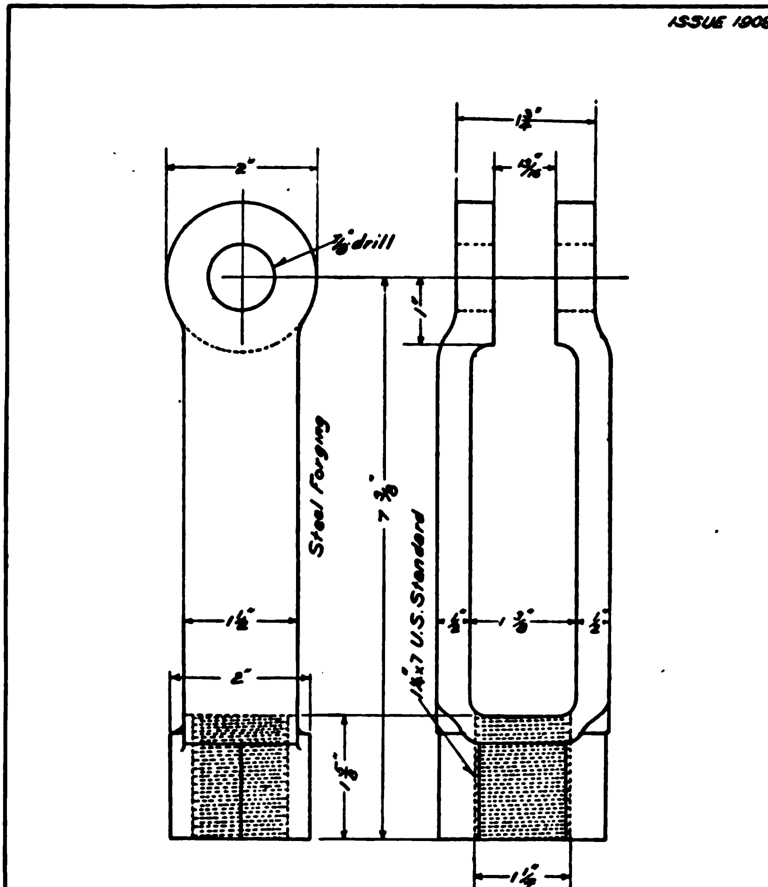
ISSUE 1908.



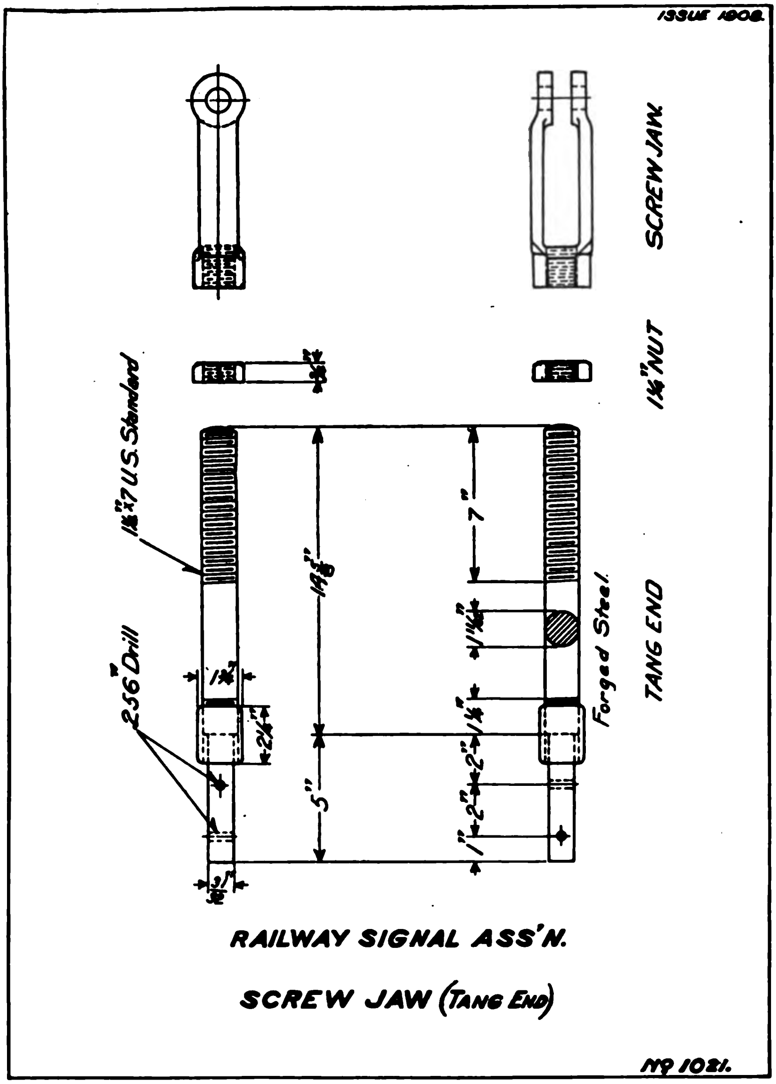
RAILWAY SIGNAL ASS'N.
WIDE JAW (TANG END).

Nº 1018.


ISSUE 1908.
.266" drill
.266" drill
Forged Steel
Dimension A is $1\frac{3}{4}$" unless otherwise specified
$19\frac{1}{8}$"
$2\frac{1}{8}$"
$1\frac{3}{4}$"
RAILWAY SIGNAL ASS'N.
SLOTTED JAW (TANG END).
Nº 1018.

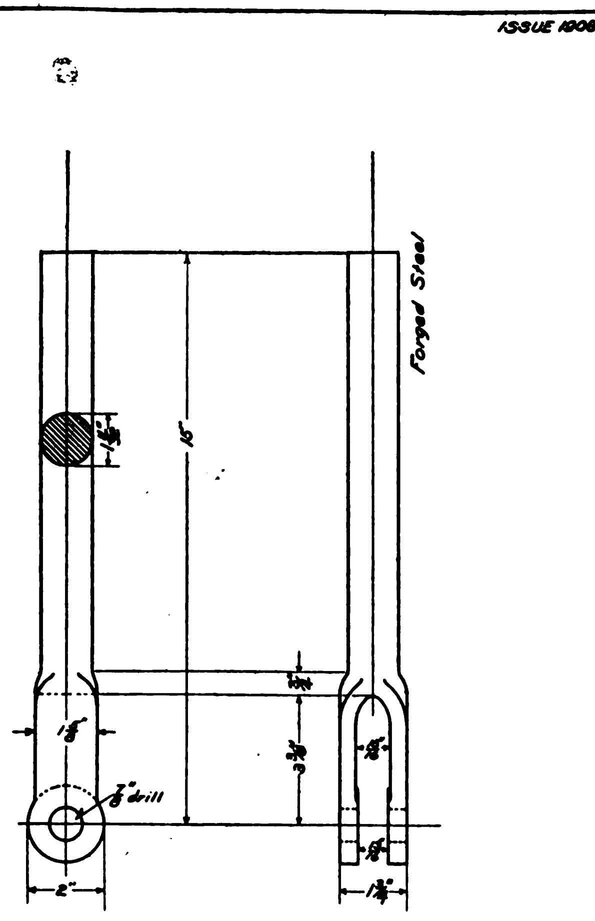


RAILWAY SIGNAL ASS'N.
SCREW JAW.



RAILWAY SIGNAL ASS'N.

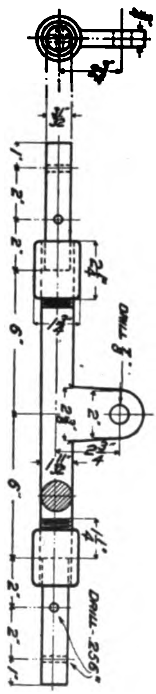
SCREW JAW (TANG END)



RAILWAY SIGNAL ASS'N.
SOLID JAW (BUTT END).

Nº 1022.

ISSUE 1908

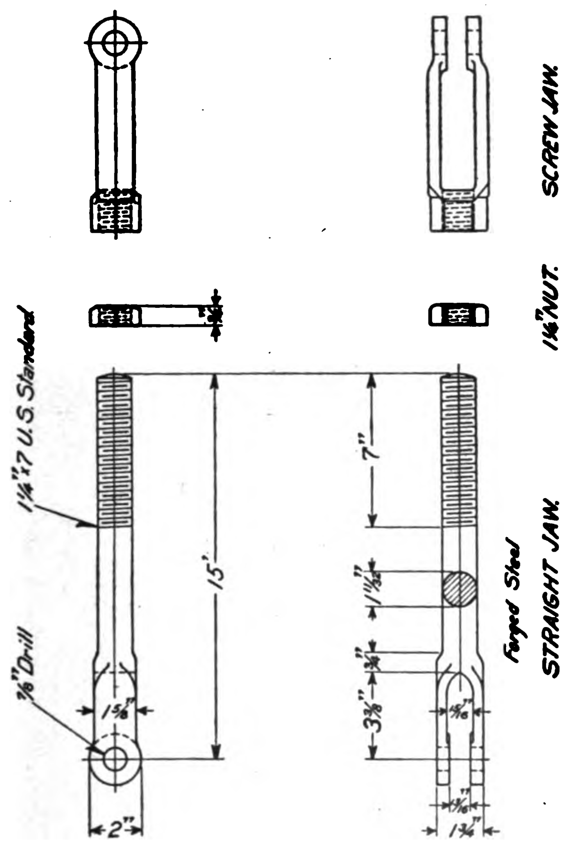


RAILWAY SIGNAL ASS'N.

LUG, TANG ENDS FOR 1" PIPE-STEEL FORGING.

Nº 1023

ISSUE 1908.

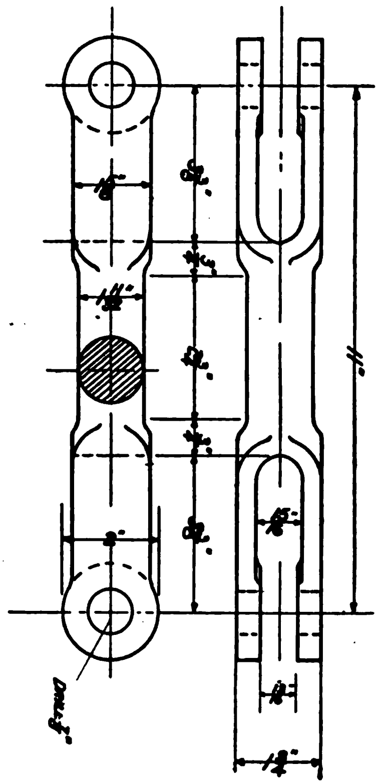


RAILWAY SIGNAL ASS'N.

STRAIGHT AJUSTABLE LINK

No. 1024.

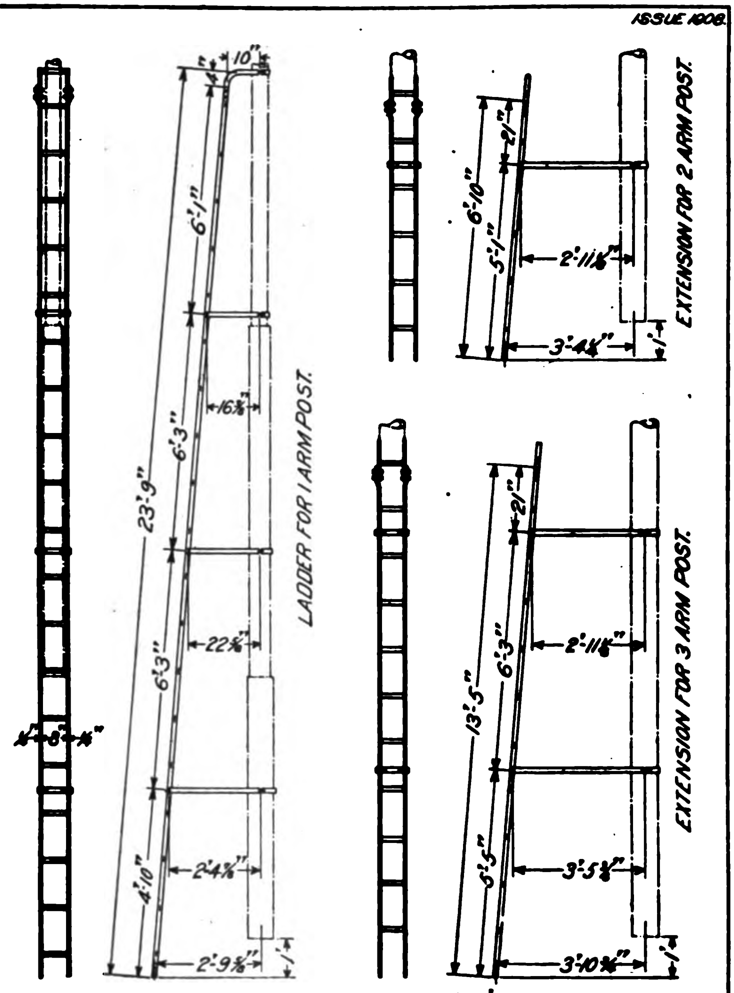
ISSUE 1908.



RAILWAY SIGNAL ASS'N.

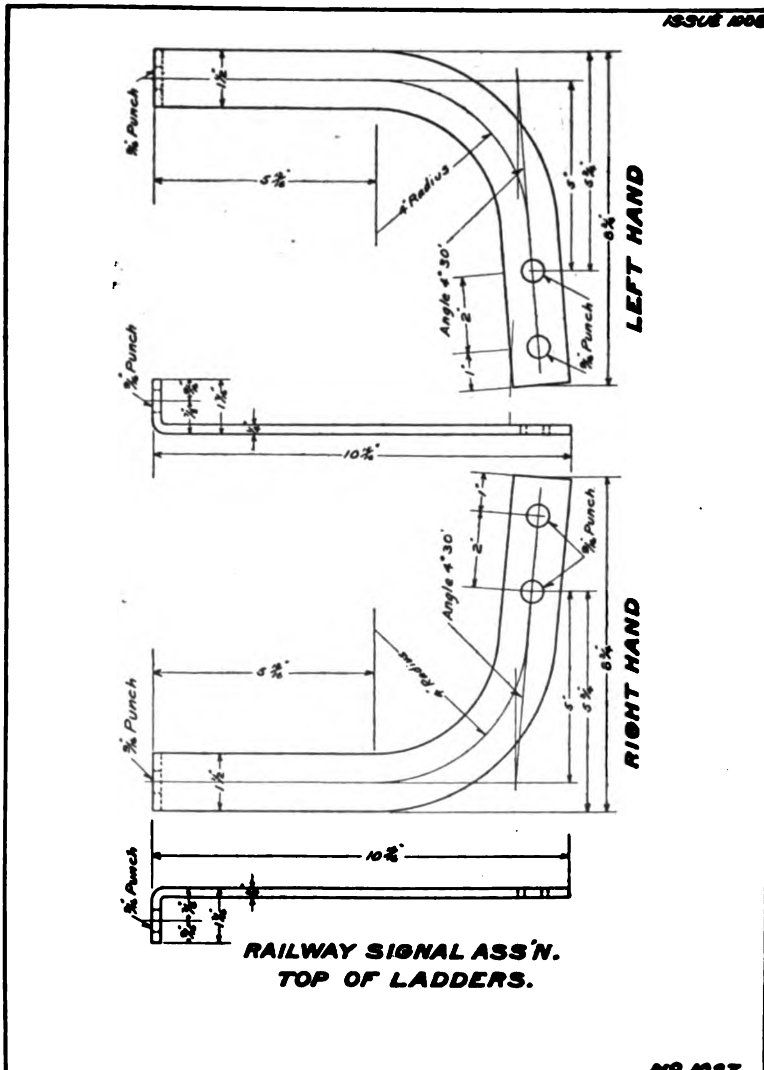
SOLID LINK - STEEL FORGING.

No 1025.

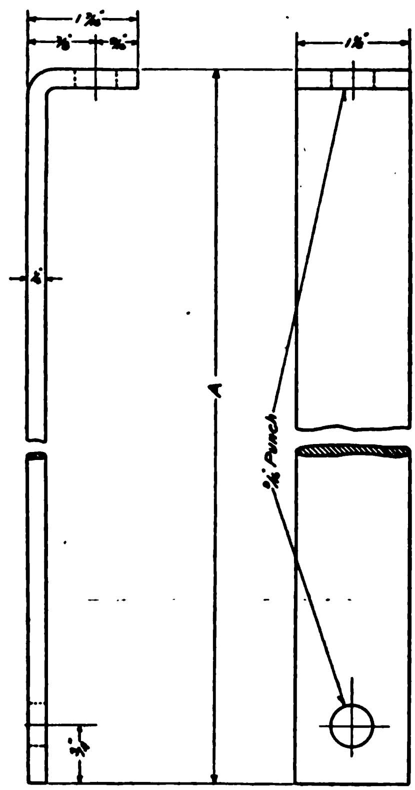


RAILWAY SIGNAL ASS'N.
STANDARD LADDERS FOR PIPE SIGNAL POSTS

Nº 1026.


LEFT HAND
RIGHT HAND
Radius
Angle 4° 30'
Punch
RAILWAY SIGNAL ASS'N.
TOP OF LADDERS.
Nº 1027.

ISSUE 1908

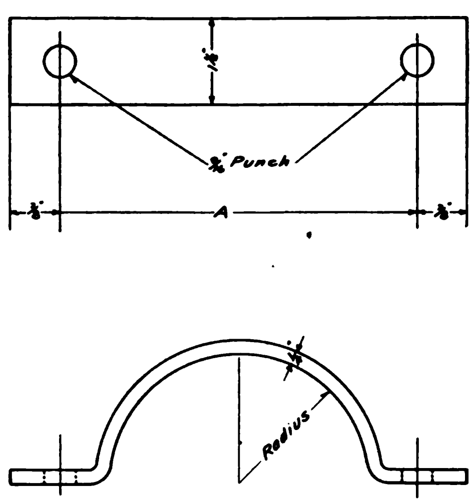


A = variable

RAILWAY SIGNAL ASS'N.
SIDES FOR LADDER STAYS.

No 1028.

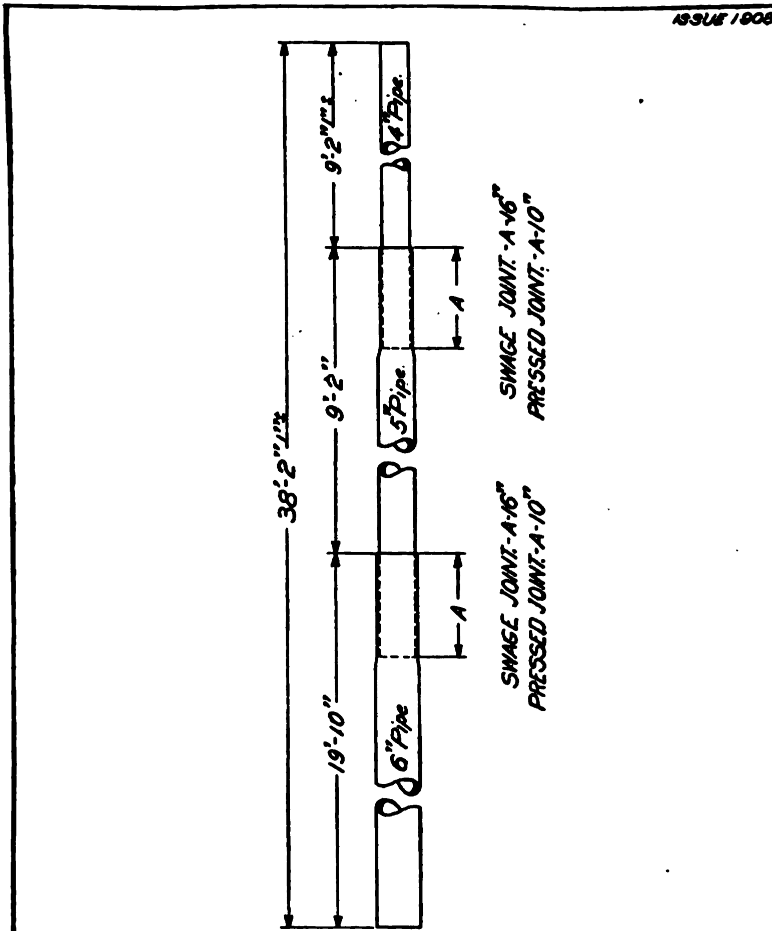
ISSUE 1908.



Part	For	Radius	A
1	4" Pipe	2¼"	6¾"
2	5" "	2¾"	7¼"
3	6 "	3⅛"	8⅛"

RAILWAY SIGNAL ASS'N.
FRONT & BACK CLAMP
FOR LADDER STAYS.

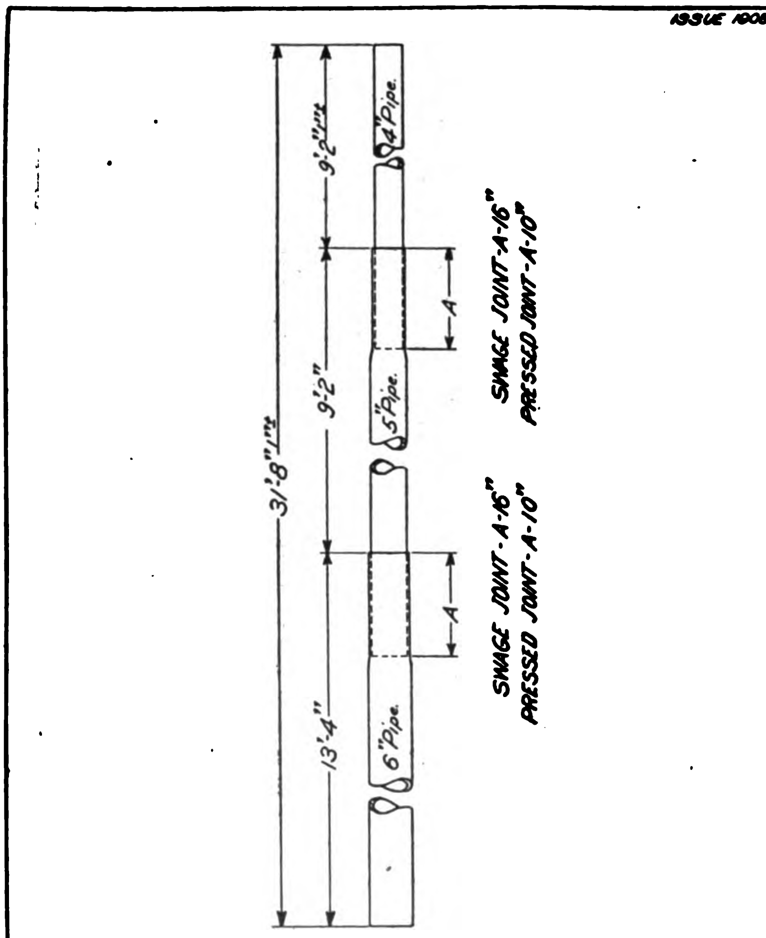
No. 1020



RAILWAY SIGNAL ASS'N.

STANDARD PIPE SIGNAL POST

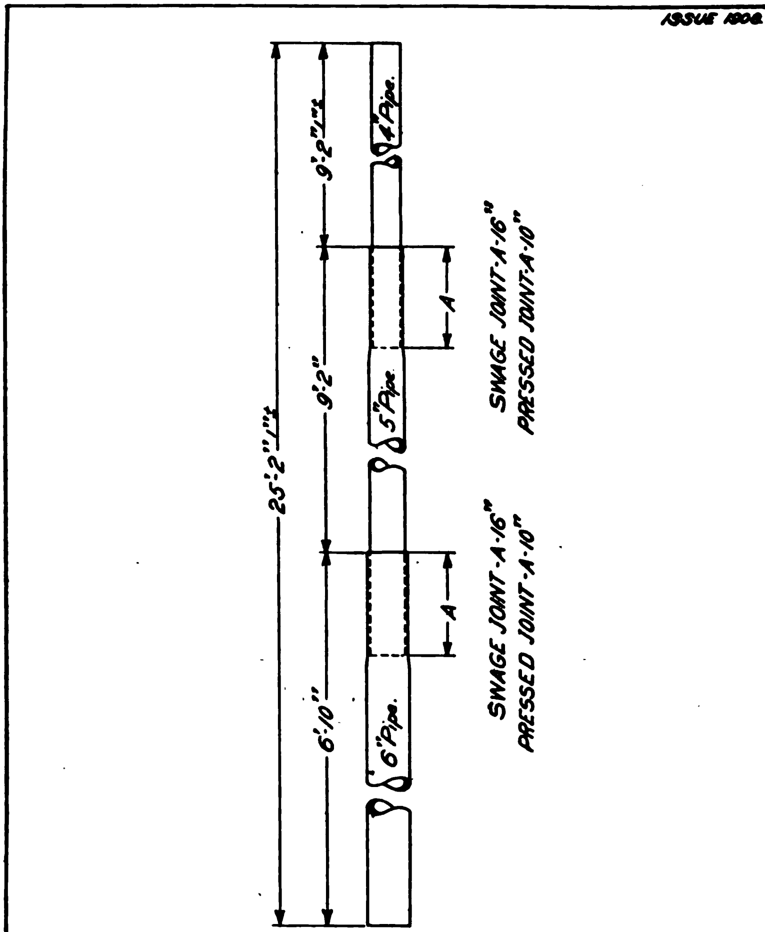
Nº 1030.



RAILWAY SIGNAL ASS'N.

STANDARD PIPE SIGNAL POST.

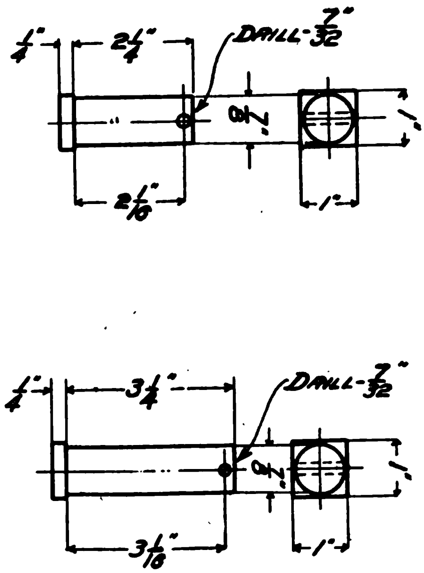
No. 1031.



RAILWAY SIGNAL ASS'N.

STANDARD PIPE SIGNAL POST.

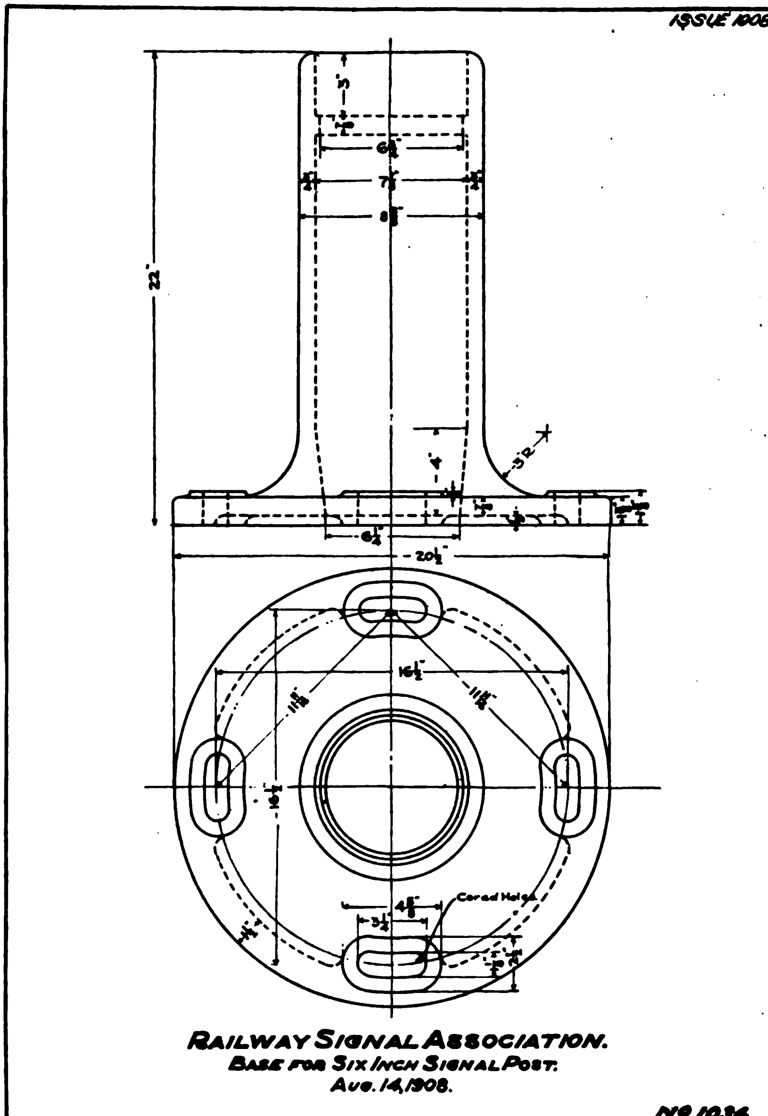
ISSUE 1908.



RAILWAY SIGNAL ASS'N.

JAW PINS.

No. 1033.


ISSUE 1908
Cored Holes
RAILWAY SIGNAL ASSOCIATION.
BASE FOR SIX INCH SIGNAL POST.
AUG. 14, 1908.
Nº 1034.

DISCUSSION.

Mr. A. H. Rudd (Pennsylvania Railroad):—There were six subjects specifically assigned to the Committee on Signaling and Interlocking. It is a pretty heavy load for one man to carry, and I have asked Mr. Anthony to take care of the first division, Mr. Clausen the second division, Mr. Ames the third division, Mr. Rhea the fourth division, the chairman the fifth division, Mr. Mock the sixth division, Mr. Stevens the seventh division and Mr. Peabody the eighth division, because they handled those subjects in Committee, except that the mechanical interlocking specifications were handled by the Mechanical Interlocking Committee of the Railway Signal Association; Mr. Kelloway, the chairman of the Mechanical Interlocking Committee of the Railway Signal Association, is here; the electrical specifications were handled by Mr. Mann, also a member of the Railway Signal Association, who is also here to-day. In the absence of Mr. Clausen, Mr. Mann will answer any questions in regard to subject 2.

There is one correction to be made in the list of sub-committees. In the sub-committee on Aspects, Mr. Anthony has been substituted for Mr. Peabody.

Subjects 1, 2 and 3 have all been acted on by letter ballot of the Railway Signal Association and all adopted as specifications. They are altogether too voluminous to discuss by paragraphs here, and the Committee simply hopes that this Association will endorse the action of the Railway Signal Association. Subject 4 should be brought up for argument, and subject 5 is a progress report.

The President:—Too frequently in our conventions the individual members of the Committee have nothing to say. They occupy honorable positions on the platform, but they assign the speaking to the chairman. Mr. Rudd's idea is commendable.

Mr. Rudd:—It is important we should proceed with the reports as they are here.

The President:—The chair will ask the chairman of the Committee for a suggestion as to how he wishes this particular report brought up before the convention. It is, as he says, very voluminous. It is important to economize as much time as possible, but yet it is most desirable to get all the essential features out of the report brought before us.

Mr. Rudd:—I am sorry that Mr. Rhea, who had charge of the subject, is not here, but I suggest in his absence that we start by reading the sample agreement, or proceed by paragraphs, if desired to dispense with the reading of the sample agreement. This particular branch of the report is presented with the idea of getting discussion from the members of the Association.

Mr. L. C. Fritch (Illinois Central):—I do not quite understand whether the first, second and third subjects have been passd upon, whether these specifications for mechanical and electrical interlocking plants, or the specifications for rubber-covered wire have been passed upon by this Association. If not, is not that in order?

Mr. Rudd:—I think we could proceed as printed in the book. Subjects 1, 2 and 3 have not been passed upon by the Association, except that some two years ago we adopted mechanical specifications—we never have adopted electrical specifications, we have waited two years for the action of the Railway Signal Association—and we have never adopted rubber-covered wire specifications. The mechanical specifications submitted are at great variance with the present mechanical specifications of this Association. They will probably have to be changed in certain immaterial respects next year, but the specification as it now stands, as completed by the Signal Association, is so much better than the specification we have that I think it should be adopted as a whole, and I, therefore, move the adoption of the mechanical interlocking specifications as presented.

Mr. C. H. Ewing (Philadelphia & Reading):—I would ask the Committee when the specifications were adopted by the Railway Signal Association, and if they have been tried out so as to eliminate the possible defects in a specification which has been recently drawn?

Mr. Rudd:—The specifications were submitted to letter-ballot last October and have been adopted by letter-ballot. There is one thing about specifications for mechanical interlocking that we felt pretty sure of, and that is, that the mechanical interlocking specifications have passed the experimental stage. Mechanical interlocking is not a new thing, and we have been using specifications for the last ten years, each year making progress, so I do not think there will be any difficulty in carrying out the specifications as at present submitted, because there are, as far as I know, no innovations, it is simply a matter of bringing them up to approved practice. There may be some particular point that Mr. Ewing has in mind.

Mr. Ewing:—In reading over the specifications prior to this meeting, I find that the Committee has excluded the use of wrought-iron pipe and have recommended specifications which permit the use of steel pipe only. I would like to bring out that point, as it seems to me a very important one, and ask the Committee why they thought wrought-iron pipe should be excluded from these specifications.

Mr. Rudd:—I think it would take two hours to tell all the reasons why, but to sum up the plain English of it, without any reflections on anybody, the signalmen have been fooled about wrought-iron pipe for the last ten years. The wrought-iron pipe we have been receiving has been made of mild steel. It is a strange thing, but it is true. We paid for wrought-iron pipe and got mild steel. If we order steel we pay a less price and get better pipe, because some wrought-iron pipe is made of a very poor grade of steel.

Mr. Ewing:—The chairman's admissions prove to my mind that we should include in these specifications a specification for wrought-iron pipe. If we specify mild steel only we will get bad steel; if we include wrought-iron we will get better pipe. It is a matter of considerable importance, and I think one that justifies the very fullest discussion. Any serious attempt to discuss the merits of steel and iron in this convention at this time would take the entire day and perhaps to-morrow; but I venture the assertion if the matter is left to a choice of the majority of the members here, as to the use of wrought-iron or steel, men who have had an opportunity of using both, the majority will vote in favor of the iron.

Mr. J. C. Mock (Detroit River Tunnel Company):—The subject was assigned to a sub-committee, and their first draft of a specification called for steel. We have made a drawing, which is to accompany the material specification, and we have explained to the trade that this drawing will be used for a specification for wrought-iron. What the chairman has said is true; in our study we found that a great deal of pipe which had been received by the railroads and known by them as wrought-iron, after test has been found to be of soft steel. The specification, as submitted to this Association, is changed somewhat from the form in which it was originally written, to raise the tensile strength and limit the elasticity in order to raise it above what could be used for the wrought-iron specification. It is the intention of the sub-committee on Standards to prepare a specification for wrought-iron pipe, but thought this one should be tried out first, and if we can get pipe in accordance with these specifications it will be all right. After carefully going into the merits of the black and galvanized pipe, the Committee decided it would be better to call for galvanized pipe. Of course that clause can be omitted from the specification by anyone desiring to use black pipe.

Mr. W. C. Cushing (Pennsylvania Lines):—Clause 30 says: "The body of all jaws shall be of wrought-iron." Is that mild steel?

Mr. Rudd:—No, it is not, Mr. Cushing, and the jaws are not the pipe.

Mr. Ewing:—I call attention to the Committee's recommendation that all pipe posts shall be made of wrought-iron.

The President:—Give your reference, Mr. Ewing, so that the members can refer to it.

Mr. Ewing:—It is under the heading of poles, "straight pipe posts shall be made of certain sizes of wrought-iron pipe."

Mr. Mock:—I think it would be well to say that the specifications for the various interlocking installations have been made by various committees, and the commercial term employed is "wrought-iron," while, as a matter of fact, it is soft steel, and in these pipe specifications we intentionally change to the word "steel," although I think in some of the drawings marked "wrought-iron" it is well known that what we get is a mild steel. The Committee on Standards of the Railway

Signal Association is harmonizing these various specifications, the purpose being to cut out these little inconsistencies.

Mr. Rudd:—Perhaps it will help Mr. Ewing to state that the trade name is wrought-iron pipe as distinguished from cast-iron pipe. The detail specifications for material is shown, specifying for 1-in. pipe a coupling of a certain dimension—that is, where the steel comes in—the other is known by the trade name, and there is no detail specification as to how it shall be made.

Mr. Ewing:—I have taken the specifications literally. There are reliable manufacturers to-day who are manufacturing exclusively wrought-iron pipe of a very high grade. The only advantage that I have heard mentioned in favor of the steel is its greater tensile strength—elongation. That is no test of durability. Our experience is that the wrought-iron pipe is very much more durable than steel pipe. Steel pipe with a high percentage of manganese begins to pit very soon after it is used. That pitting continues at a very rapid rate and the deterioration is very rapid. Wrought-iron does not deteriorate nearly so rapidly as the steel pipe. Furthermore, I believe that the wrought-iron pipe is safer than steel. Steel pipe, under alternate compression and tension, breaks at the root of the thread. Wrought-iron pipe will not; so that I feel it would be a great mistake for this Association to pass the specifications for steel pipe only. I firmly believe that genuine wrought-iron pipe is a much better article.

The President:—Do you make a motion to that effect?

Mr. Ewing:—I would move that the Committee prepare specifications for wrought-iron pipe, to be included in the specifications along with steel pipe.

Mr. Rudd:—Do I understand by that that those will be adopted without coming before the Association, or will the specifications for steel pipe be rejected and not appear in the Manual and held over until such time as we have specifications for both? The Committee might prepare specifications for wrought-iron pipe, which would substitute the words "wrought-iron" instead of soft steel and be just the same all the way through, because this is practically what we have been getting as wrought-iron for some time.

Mr. Ewing:—I believe that these specifications might properly go over another year and have revised specifications prepared for submission at the next annual meeting. Our specifications, as printed in the Manuai, as I recall them, were only adopted at the last meeting. Now, we are called upon to adopt new specifications which have not been tried out, and I think in view of these objections we might very properly allow these specifications to go over for this year.

The President:—Mr. Ewing, would you change your motion to one recommitting these specifications to the Committee with instructions to prepare a specification for wrought-iron pipe?

Mr. Ewing:—Yes, sir, I would make that as a motion.

The President:—Are you ready for the motion, to refer back this specification for mechanical interlocking to the Committee in order that they may prepare a specification for wrought-iron pipe along with steel?

Mr. W. G. Besler (Central Railroad of New Jersey):—I quite agree with the remarks made by Mr. Ewing, and I hope his motion will prevail and that the members will give consideration to their interests and assist in that direction.

The President:—Are you ready for the question?

(Motion carried.)

The President:—The specifications for mechanical interlocking are referred back to the Committee, with instructions to prepare a specification for wrought-iron pipe. The chair asks the chairman to have the subject of interlocking specifications presented.

Mr. Rudd:—I presume it will be the sense of the Association to refer the power interlocking specifications back for another year, because they are newer than the mechanical specifications and have been drawn up with only four or five years' practice. They are somewhat experimental, in a good many ways, and if it is to be the idea that we will not adopt any specifications until they have been tried out in practice by somebody, it will be difficult to present a specification on a new subject.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I move that the specification on electrical interlocking be received as a progress report.

Mr. Chas. S. Churchill (Norfolk & Western):—I second the motion.

(Motion carried.)

Mr. Rudd:—The subject of rubber-covered wire has been discussed in the Railway Signal Association several years. The specifications were adopted two years ago, and a year ago the matter was referred back to the Committee and this year there were a few slight changes made in the report and it was adopted again as the specifications, so that these specifications, with very slight changes, have been in use and some roads have had them in use for four years. If the Association feels that that is long enough I think the Committee would be glad to see them adopted.

Mr. L. C. Fritch:—I move the specifications for rubber-covered wire, as submitted by the Committee, be adopted by this Association and printed as specifications in the Manual.

Mr. Besler:—I second the motion.

(Motion carried.)

Mr. Rudd:—The next is "Standard Interlocking Agreement for Signal Work." Mr. Rhea, who had that in charge, is here. Mr. Rhea may want to say something about this.

Mr. Frank Rhea (General Electric Company):—This, as you will notice, is a progress report. The purpose of the report is, largely, to enable the Association to take definite action as to what shall be the basis of division of the various component parts of the expense

of constructing, maintaining, renewing and operating interlocking plants. We have entitled it an agreement, as it is actually more than a contract; it is perpetual. We have undertaken to give conclusions here which will enable the Committee then to draw drafts of agreements which will be in accord with the accepted basis for the division of expense. That is really the purpose of this progress report, as we feel it would be rather futile to give a final report, leaving unsettled as to what shall be the controlling basis of the divisions, and we felt it was necessary for us to have the Association settle, from the standpoint of principle, how the expenses should be divided. We will then draft our agreements in the various forms to comply with the sample printed. That is really the purpose of the progress report, as now presented, and it is the desire of the Committee that you give us a definite expression on the conclusions we have presented, or that you give us alternate principles to take their place, in definite form, so that we can then proceed with the conclusion of a final report. I think it is possible either to indorse the conclusions which we have made or by substitution and amendments, suggest the principles which shall prevail. I think that that will come out in a discussion of the report if it takes place. You can either endorse the principles which we have presented or you can amend them and give us an expression of what you want us to do; in other words, outline the principles which you want us to follow.

The President:—The chair would ask the chairman if the Committee has had any conference with the Committee on Uniform General Contract Forms with regard to the preparation of this form of contract.

Mr. Rhea:—No, sir; we have not had any conferences with the Committee on Uniform General Contract Forms.

The President:—What do you wish to do with this progress report, this sample agreement?

Mr. McDonald:—I move that it be considered by paragraphs.

(Motion carried.)

The Secretary:—"Sample Agreement—Class A. Preamble. This Agreement, made and entered into this .... day of .... A. D., by and between the A and B Company, hereinafter called the X Company, party of the first part, and the C and D Company, hereinafter called the Y Company, party of the second part.

Witnesseth:

"Whereas, the roads of the respective parties now intersect and cross each other at ...., as provided for in an agreement made and entered into the .... day of .... A. D., by and between the E and F Company of the first part and the G and H Company of the second part, of which the said X Company and said Y Company are the respective successors, and

"Whereas, the parties are mutually desirous of erecting, renewing, maintaining and operating an interlocking plant at said crossing to

facilitate and render more safe the passage of trains over the same, the location of said crossing being identified, and the said interlocking plant to be arranged as shown upon blueprint dated ......, identified by the signature of the .... Engineer of the first party, and the .... Engineer of the second party, attached hereto, marked Exhibit 'A,' and hereby made a part of this agreement, and

"WHEREAS, the parties hereto have agreed upon the terms and conditions upon which said interlocking plant, as shown by said Exhibit 'A,' shall be constructed, renewed, maintained and operated;

"NOW THEREFORE, in consideration of the premises, and in further consideration of the mutual covenants and agreements hereinafter stipulated to be kept and performed, it is agreed between the parties for the purpose of defining the terms and conditions upon which said interlocking plant shall be constructed, renewed, maintained and operated, as follows:

"First—The said X Company agrees to construct an interlocking plant as shown upon said Exhibit 'A,' and in accordance with the specifications to be approved by the above-named Engineers, under the operation of which trains of either party may, pursuant to the laws of the State of ...., pass over the tracks of the other party without coming to a stop. The cost of removing any existing safety devices or appliances shall be divided in like manner, as the cost of the former renewal and maintenance expense of said devices or appliances has been heretofore divided.

"Second—The cost of constructing, renewing and maintaining said interlocking plant, as shown upon said Exhibit 'A,' shall be borne on an operated unit basis by the parties hereto in the proportion that the total number of operated units used to interlock the tracks of each of the respective parties, bears to the total number of operated units of the complete interlocking plant, as shown by the table of operated units on said Exhibit 'A.'

"Third—(a) The cost of operating said interlocking plant, as shown by said Exhibit 'A,' shall be borne equally by the parties hereto.

"(b) The cost of operating said interlocking plant shall be borne as follows:

"Said .... Company shall pay the sum of .... Dollars ($......) per month, the amount which it now pays for railway crossing watchmen, their supplies, and maintenance of railway crossing gates; the balance of said operating expenses shall be divided equally between the parties hereto.

"NOTE—(a) and (b) to be used as circumstances require.

"Fourth—All extensions or changes of said interlocking plant arising from changes made in any existing track or tracks, or made to cover any future track or tracks or connections which either party may have the right to construct, or which may be required by reason of any changes made in the standard appliances of either Company, or ordered by proper authority, shall be made by said X Company and the first

cost of such extensions or changes shall be borne by the party hereto for whose benefit said extensions or changes are made, and the amount chargeable for renewal and maintenance to each party in such case is to be determined by the proportion which the total number of operated units then used to interlock the tracks of each of the respective parties, bears to the total number of operated units of the complete interlocking plant."

Mr. Ewing:—I just want to bring up a little discussion on one of these points. I do not quite catch what is intended by the third paragraph. As I take it, that could not apply to a grade crossing, for instance. A road crosses another road at grade, and if this paragraph is adopted the new road is required to pay only one-half of the cost of the operators protecting that crossing.

Mr. Rhea:—Explanations of paragraphs A, B and C will explain that this draft of agreement is only a sample to bring out the views of the members, and that it covers only the building of an interlocking plant at an existing crossing. It is not intended to cover the operation or construction of a plant, either where a new road crosses two existing roads at an interlocking, or where a new road crosses an existing road. Those are to be covered by B and C, which will have to be different agreements. You cannot make a universal agreement covering three types of conditions. A point, however, that will probably come up in our conclusions, one of the principal points that we want settled, is whether we will have a different method of dividing operation than we will for construction, maintenance and renewal. In other words, articles 2 and 3 are very critical points in this agreement and the principles involved therein.

Mr. Ewing:—If this question will come up later, as to dividing the cost, I will not have anything more to say on the subject just now. As I understand Mr. Rhea, that question will appear a little later in our conclusions.

Mr. Rhea:—We intend to bring that out pointedly in our conclusions. Our conclusions are the gist of the proposition.

The Secretary:—"Fifth—The renewal and maintenance of said interlocking plant shall be under the sole charge and control of said X Company, and it shall employ competent persons to renew and maintain the same, and such parties from time to time so employed shall be considered as joint employés of the parties hereto and shall be removed for good and sufficient reasons upon request in writing of the general managing officer of the said Y Company.

"And it is further mutually agreed and understood that in event said Y Company shall in writing notify said X Company of renewals and repairs that may be necessary for the safe and proper operation of the said interlocking plant, and if said X Company neglects for a period of 30 days to make said necessary renewals and repairs, then said Y Company shall have the right to make such renewals and repairs, and

said X Company, upon presentation of the proper bills therefor, will pay its proportion of the amount so expended."

Mr. Rhea:—I think there is a point here that is not covered in our conclusions. That is rather an unusual provision in interlocking agreements as they exist to-day. There has been a great deal of trouble caused by one road not properly maintaining interlocking, in not only endangering its own traffic, but endangering the traffic of the other interested parties. There were quite a number of suggestions made as to how it should be covered. We think this is one of the best ways to cover it, although we are not exactly sure it is the best. It is a good way, but I would like to call your attention to that point, as it is an unusual provision in existing interlocking agreements. As far as I know there are very few, and they are very exceptional cases, where that is provided. I do not think I know more than about three cases in all my experience where that has been provided. One came up and the Committee decided that we, in formulating this sample agreement, at least call attention to it, as we think it is a very essential point.

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—I think this point will cause a lot of trouble. There is a difference of opinion among signalmen as to what is good practice; what stands on one road will not stand on another. If the Committee will incorporate somewhere in this contract that the standards of the Railway Signal Association or of this Association would be sufficient for either road, there would be some place to draw the line, but my experience has been that what we think is good practice and safe might not suit our neighbors. Under this system they might tamper with the interlocking.

Mr. Rhea:—I think the Committee have particularly fortified themselves on that point. This is not a case of change of standards or anything of the kind. That is thoroughly covered in article 4. It is simply a question of the maintenance of your existing apparatus, and when you have accepted a plant, you have tied yourself up to pay for all improvements that your changes of standards in the future may require. That is covered by article 4, and it is so intended. This is purely and strictly a case of proper maintenance of your existing apparatus, that they shall be safe for the operation of your railroad. If you do not renew your foundations or have a detector bar that is partly missing or similar conditions, it is the obligation of the maintaining company to replace and keep the plant as it previously existed, keep it in safe condition, because the purpose of this report is to maintain it in that condition. It is not to make provisions for changes or for standards of erection, which is also covered by a previous paragraph which gives each road interested the right to approve the specifications and plans before the plant is constructed.

Mr. L. C. Fritch:—The Committee has further safeguarded this point by introducing an arbitration clause. If there is any question as

to the rights of the respective parties it can be submitted to arbitration. It seems to me this clause is covered very well by existing agreements. There is always protection in the use of trackage by the agreements. If the tracks are not in safe condition the second party usually has the right to make such repairs and charge the first party with its proportion of the expense.

Mr. Rhea:—I might say that Mr. Fritch has made a very good point and the Committee merely took advantage of precedence in the line that Mr. Fritch spoke about. We have ample precedence in other forms of agreements for what we have done here.

Mr. John V. Hanna (Kansas City Terminal):—Before we pass on from here I would like to make a suggestion, that in providing for payment of bills a time limit should be inserted. I think it would be advisable in the contract to say within a certain time, thirty or sixty days, and also that the word "shall" is preferable to "will" in that connection. "Shall" would be mandatory; the word "will" simply indicates it may be done at some indefinite time.

The President:—The chair assumes that this general contract will be brought into line with the phraseology, as far as possible, of the Committee on Uniform General Contract Forms.

The Secretary:—"Sixth—The operation of said interlocking plant shall be under the sole charge and control of said X Company, and it shall employ competent persons to operate the same, and such persons from time to time so employed shall be considered as joint employés of the parties hereto and shall be removed for good and sufficient reasons upon request in writing of the general managing officer of the said Y Company; and it is further mutually understood that either Company may use the signalmen in its telegraph or telephone service; but in event additional expense is so incurred, on account of increased wages of operators over levermen, the Company using the operators in its service shall bear the additional expense."

Mr. Rhea:—I would like to call your attention to two points here, which are not principles involved in our conclusions. The first is that we have made it read "the general managing officer." There have been entailed hardships in a few instances by one road insisting on the discharge of operators, whereas if that had had to go through the general managing officer it would probably never have happened. The other point is that we provide for one road using the employés in additional service, and in event of that service costing more, the road getting the benefit of it should take the burden of additional expense. In quite a number of cases that has caused trouble. I simply call your attention to these points which we have here incorporated.

The Secretary:—"Seventh—The salaries of employés connected with maintenance, renewal and operation of the interlocking plant shall be the same as the standard salaries paid by the X Company for similar

service to its other employés in the territory of the said X Company's .... Division."

Mr. Rhea:—That is another provision which has not been general. I do not know that we have very much precedent for adopting this, as in the case of paragraph 5, but I have known quite a number of cases where that has been a very fruitful source of misunderstanding as to the salaries to be paid. I think that the railroads are usually, to a very great extent, getting to a basis of what you can term standard wages for their particular territories. This I think ties it down and makes it equitable to the parties interested. I have had personal experience with roads that have deliberately held up increases which were as much, if not more, necessitated by their requirements than the road having actual charge of the plant. These, of course, and all other possible sources of difficulty, can be arbitrated under the arbitration clause, but it is a good deal better and will eliminate trouble if you have those points explicitly covered.

The Secretary:—"Eighth—The payment of all bills under this agreement shall be made not later than the twenty-fifth day of the month following the month in which said bills are rendered. The bill for expense of construction shall be made as a final bill, unless otherwise mutually agreed and understood. In the event that partial bills for expense of construction are rendered, each such partial bill shall not only show fully the part of the construction expense to be paid by such bill, but shall also include a statement of all construction expense which has been covered by any partial bills which may have been rendered and paid previously."

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—I want to call attention to the fact that any provision requiring the payment of bills on the twenty-fifth day of the month following is not a provision which can be carried out in all instances. I have knowledge of conditions under which that could not be complied with. I would suggest to the Committee that they substitute "within a reasonable time."

Mr. Rhea:—The wording of that paragraph is that the payment of all bills under this agreement shall be made not later than the twenty-fifth day of the month following the month in which said bills are rendered. That gives you about fifty-five days, in some cases. In other words, it takes you past the rush period in one month. If it is rendered the last day, you have at least twenty-five days to pay your bills. It is not the twenty-fifth day of the month rendered, but the twenty-fifth day of the following month, which seemed to us a sufficiently reasonable time. I would like to call your attention to another paragraph, for which Mr. Peabody is largely responsible, but with which I fully agree, that bills for the expense of the construction shall be made as final bills. That is rather an unusual suggestion, but I have experienced a good deal of trouble in having partial bills checked and I resorted some time past, in cases where I anticipated having trouble, to making a final bill, and I got out of it with a good deal

less trouble and expense than if I had saved the per cent. on the money during the interval. The constructing company is allowed a percentage as a general practice, and that percentage, in our opinion, is sufficient to enable them to hold those bills in suspense until they are able to handle it in this way. If they were so slow in building a machine that it takes a couple of years, it is probably their fault and not the fault of the other parties; but the party checking the bill is put in much better position if given a final bill, or is given, in partial bills, a complete statement up to that date. If you undertake to check up a few interlocking bills, I think you will appreciate the force of this suggestion.

Mr. A. S. Baldwin (Illinois Central):—There is another suggestion in connection with the payment of these bills. I think the time allowed is sufficient under ordinary circumstances, but we have all been troubled by the custom of delaying the payment of a bill on account of probably one or two disputed items, and I have known such delay to be claimed as causing breach of contract. I have made it a custom recently to provide that bills should be paid before a certain date, unless there are disputed items, under which circumstances the disputed items are to be withheld and the remainder of bill paid on day specified.

The Secretary:—"Ninth—In making bills for the cost and expense of construction, renewing and maintaining said interlocking plant, all labor and material shall be charged for at actual cost, plus .. per cent. added to material and .. per cent. to labor for handling, superintendence, use of tools and accounting.

"The labor for the operation of said plant shall be charged for at its actual cost, without the addition of any percentage.

"Note.—Your attention is called to the fact that no provision is made for the $5 monthly charge, provided for in the rules of the General Managers' Association of Chicago. Your Committee feels that this charge should be discontinued, for the reason that this is an organization charge."

Mr. Rhea:—There is possibly a principle involved. We have had some criticism on this paragraph by some legal people and they doubted the advisability of putting that paragraph in. Personally we think it should go in. Their objection to it is that there are local arrangements—for instance the Chicago General Managers' Association may have one set of rules, and some other local association or territory may have another, and they objected to it largely on that ground. We do not think the objection is good; therefore, we put it in.

The Secretary:—"Tenth—Each of the parties hereto will, without cost to the other, furnish and install its own derails, switch rods, special switch and derail timbers, insulated track joints, cross-arms, pins and insulators, and will renew and maintain them from time to time thereafter; likewise, without cost to the other party, do all the

trackwork and grading along its own tracks necessary to prepare the same for the installation of said interlocking plant, and will also provide and maintain proper drainage upon its right-of-way.

"Eleventh—Each of the parties hereto will at its own expense keep all switches and derails in its own tracks free from ice, snow, dirt or other obstructions which may interfere in any way with the proper working of said interlocking plant, and in case either party fails so to do, the other party shall have the right to enter upon the premises of the party at fault and remove such ice, snow, dirt or other obstructions, in which event the party at fault shall reimburse the party doing such work for all expense thereby incurred, plus .. per cent. to cover superintendence, use of tools and accounting.

"Twelfth—Each party hereto shall pay for all loss, damage and expense caused by its separate agents or employés, either to the interlocking plant, to the property of the other party, or to others not parties to this agreement.

"All loss, damage and expense caused by the individual negligence of employés connected with the construction, renewal, maintenance or operation of the interlocking plant, or by the combined negligence of such parties hereto, or by failure of any part of the interlocking plant, shall be borne and paid for by the party hereto that may be using the interlocking plant at the time such loss, damage and expense occurs, and, if same shall occur while the trains of both of the parties hereto are at the crossing, or shall be caused by the combined negligence of the separate employés of the parties hereto, each party therein involved shall hear and pay for all loss, damage and expense caused to its own property, or to persons or property in its charge; all other loss, damage and expense caused as above shall be borne and paid for equally by the parties therein involved.

"Thirteenth—It is further distinctly understood and agreed that any and all agreements relative to said crossing existing between the parties hereto, or their predecessors, so far as they conflict, or are inconsistent with the terms and provisions of this agreement, are hereby annulled, but in all other respects shall continue in force and virtue."

Mr. L. C. Fritch:—I want to ask the Committee if they had legal advice on the liability clause?

Mr. Rhea:—Yes, sir; we consulted legal advice rather extensively. We do not wish to assume at all as being understood as having formulated that clause. We did, however, compare quite a number of liability clauses. We considered this to be about as near English as we engineers could understand and cover the situation in legal language. I am free to say that every time I look at it I have to read it about four times to finally recollect the points involved and get them in the order in which they should come.

Mr. J. B. Berry (Chicago, Rock Island & Pacific):—I would like to ask the signal engineers if they have considered the question of freight charges. The lawyers are construing that differently, there is

nothing said here as to how freight charges shall be paid. For instance, a road might, at tariff rates, haul material long distances that would add materially to the cost of a plant, whereas, if the other side were given a chance to furnish material, it would be hauled a shorter distance and the freight charges would be less. It seems to me we ought to have something in this contract that would stipulate how freight charges should be paid.

Mr. L. C. Fritch:—I am not quite satisfied with the liability clause. The matter is all there, but the arrangement of it is not, to my mind, as clear as it ought to be. It is usual to divide liability clauses into three parts: First, individual liability; second, joint liability, and, third, what you might call the common liability. That can be defined, it seems to me, in a little better way and divided into three classes. Standard contract liability clauses are usually divided in that way, and I would like to suggest to the Committee that they see if they cannot further modify or change the wording so as to make it a little clearer.

Mr. Rhea:—We will undertake it. I am a little doubtful as to our ability.

The Secretary:—"Fourteenth—Should any dispute arise between the parties to this agreement concerning obligations or rights of either of them hereunder, the same shall be referred to a board of three arbitrators, one to be chosen by each party hereto and the third by the two so chosen. If either party shall fail to appoint its arbitrator within fifteen (15) days after the party desiring arbitration has appointed its arbitrator, and given written notice to the other of such appointment and of the matter proposed to be arbitrated, then the arbitrator so appointed shall appoint an arbitrator for the defaulting party and the two so appointed shall appoint the third to complete the board as above provided, and said board so appointed shall hear and decide the dispute, and assess the expenses of arbitration. The decision of said arbitrators chosen in either of said ways, or that of a majority of them, shall be final and conclusive between the parties upon the matters concerning which arbitration was demanded."

Mr. L. C. Fritch:—There are many cases in which a single arbitrator might serve as well as three, and that additional provision ought to be put in: whereas, if a single arbitrator can be selected mutually satisfactory to the parties, that ought to be done. Sometimes it is quite expensive to arbitrate a matter where you have a board of three arbitrators.

The Secretary:—"Fifteenth—The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

"In Testimony Whereof, the parties have caused these presents to be executed in duplicate by their respective proper officers as of the day and year first above written."

Mr. A. S. Baldwin:—Following the line of suggestions made by

Mr. Berry, I think there should be some provision that would protect one company against excessive charges on the part of the other, whether for freight, carriage or handling, or anything else, and I would suggest a clause providing that the connecting line should have the privilege of furnishing material if it should desire to do so, or that the prices be made on such a basis so that either company could deliver the material. We have all had experience with excessive prices. Many of us have known of cases where material has been delivered at prices in excess of what they could have been delivered for.

The President:—The Committee will consider the suggestions made and give them due consideration.

Mr. L. C. Fritch:—I move that the report of the Committee relating to the contract be accepted as a progress report, and that the Committee be instructed to confer with the Committee on Uniform General Contract Forms in the matter of drafting a complete contract.

Mr. S. S. Roberts (University of Illinois):—In regard to the preamble, I think that should be made more definite. It should give, in addition to the date of execution, the place at which the contract is signed, and space should be left after the name of the company for stating whether it is a corporate or a private company; and also space should be left for giving the correct headquarters or addresses of the parties to the contract.

Mr. Rhea:—You will leave us rather adrift if you do not give us a definite expression of opinion upon what we think are the essential things.

Mr. Rose:—I would like to suggest that paragraph 13 be printed in boldface type.

The President:—Mr. Fritch's motion is that this part of the report be referred back to the Committee with instructions to confer with the Committee on Uniform General Contract Forms.

(Motion carried.)

The Secretary:—"Conclusions—(1) That existing agreements should be given due consideration in the form of arbitraries in the division of construction, renewal, maintenance and operating expenses.

"(2) That the proper division of construction, renewal and maintenance expenses is on an operated-unit basis, each party paying for what is required to interlock its tracks, or the residue, where there are existing agreements requiring fixed arbitraries.

"(3) The primary operating expense, or the residue after deducting such arbitraries as may be required by existing agreements, should be equally divided among the several parties interested. Where operating expenses are increased by facilities for the exclusive use of one party, such party for whose benefit such facilities are provided should pay the entire additional operating expense."

Mr. McDonald:—I move that conclusion 3 expresses the views of this Association.

Mr. Ewing:—I would amend that motion by having "and operating" expense follow the expense of maintenance and operation on the same division, as operated-units.

The President:—Will you repeat the motion, Mr. Ewing?

Mr. Ewing:—I wish to include the words "and operating" in connection with expenses. My motion is to eliminate conclusion 3 and substitute therefor the addition in conclusion 2, "to include operating expense." Conclusion 2 would then read: "That the proper division of construction, renewal, maintenance and operating expenses is on an operated-unit basis, each party paying for what is required to interlock its tracks, or the residue, where there are existing agreements requiring fixed arbitraries." I make that motion for this reason—in these days of adverse legislation we may be called upon at times to allow another railroad, a competing railroad, to make a connection with an existing railroad, perhaps making a crossing over the railroad. Under the terms as outlined in conclusion 3 we are forced to agree to an interlocking plant at that junction against our will, and at the same time we agree to pay one-half the cost of that plant. I believe that the conclusion is a little too far-reaching and for that reason I suggest the elimination of it.

Mr. McDonald:—Mr. Ewing's motion is pertinent to what I had in mind—I simply wanted to bring out the fact that the Committee is proceeding along proper lines. Mr. Ewing's motion is to the effect that this should not be made to apply to anything except existing crossings.

Mr. Ewing:—Operated crossings.

Mr. Rhea:—As I understand Mr. McDonald's proposition, he endorses the three conclusions of the Committee. Mr. Ewing's motion is diametrically opposite and puts the operating expense into the other typical division of being on an operated-unit basis—very radically different. That is the point of the whole situation.

Mr. McDonald:—Would it not bring out the desire of the Committee to have my motion withdrawn and take up the conclusions in their order?

The President:—The chair so orders.

Mr. Rhea:—I move that conclusion 1 be adopted.

Mr. Wendt:—There is no intention of printing that in the Manual?

Mr. Rhea:—Not yet.

Mr. W. H. Elliott (New York Central):—I ask Mr. Rhea under what head he would divide the matter of supplies—would it not be well to insert the word "supplies" after "maintenance?" There is often a question as to how the cost of supplies should be divided, and it would be well to have it stated in the agreement.

Mr. Rhea:—I think the Committee would be willing to make an amendment that would give due consideration to all expenses involved in the crossing. Our purpose is not to abrogate existing agreements, but that existing agreements shall continue in force, and a company

that has the advantage of an existing agreement will continue to have it under the changed conditions. That is the purpose and intent of this conclusion.

The President:—The Association will understand that this discussion is entirely for the information of the Committee—we are talking now of a progress report. All in favor of the adoption of conclusion 1 will say aye.

(Conclusion adopted.)

Mr. Rhea:—I move the adoption of conclusion 2.

Mr. A. S. Baldwin:—I call attention to the fact that conclusion 2, as written, might be construed by the courts to apply to new crossings about to be constructed, and I think it would be well to insert the following—"that with existing crossings, where no previous agreements are in force, the proper division of construction, renewal and maintenance expense is on an operated-unit basis," etc.

Mr. Rhea:—The Committee is willing to accept the amendment for the reason we do not believe any recommendation that we make will very largely influence the negotiators in coming situations from getting all the advantage of their tactical positions. I am perfectly willing to accept the amendment.

Mr. Baldwin's amendment would make the conclusion read: "That, with existing crossings, where no previous agreements are in force, the proper division of construction, renewal and maintenance expenses is on an operated-unit basis, each party paying for what is required to interlock its tracks—and that would entail the elimination of the last clause which reads: "Where there are existing agreements requiring fixed arbitraries."

I will say that we did not accept that particular amendment. That is not what it started out to be. The purpose of that conclusion is that we want to divide nothing else bearing on the subject of expense of construction, renewal and maintenance on an operated-unit basis. If there are any existing agreements they will have due effect; the company being obligated by them will continue to be affected by an equal expense in the future. I am willing to accept an amendment that may be worded in harmony with that sense, but I am not willing to accept any amendment that will eliminate the sense of conclusion 1.

Mr. L. C. Fritch:—I suggest that there be inserted these words: "That, in the absence of existing agreements to the contrary, the proper division of construction, renewal and maintenance expenses be upon an operated-unit basis, etc."

Mr. Rhea:—That is satisfactory. I move that it be adopted in this form: "That, in the absence of existing agreements, requiring fixed arbitraries to the contrary, the proper division of construction, renewal and maintenance expenses be on an operated-unit basis, each party paying for what is required to interlock its tracks." I would eliminate all the matter in the conclusion after the word "tracks."

Mr. A. S. Baldwin:—I still would like to have in there my first

suggestion, "that with existing crossings." That could still be construed, I think, to apply, if the court should show a desire to do so, as a suggestion from this Committee as to how new crossings are to be paid for.

Mr. Ewing:—It seems we are a little bit at sea in this matter. I do not understand that the Committee has covered the matter of crossings at all in this conclusion. Under an operated-unit basis each party pays for what is required to interlock its tracks. The road that has prior rights, has no business to interlock its own tracks for the accommodation of another railroad.

Mr. Rhea:—The intention of conclusion 1 is to protect you now and in the future.

The President:—Mr. Baldwin, have you an amendment to offer?

Mr. Baldwin:—I have.

Mr. Rhea:—This is a rewording of Mr. Baldwin's previous motion as to conclusion 2: "That the proper division of construction, renewal and maintenance expenses is on an operated-unit basis, each party paying for what is required to interlock its tracks, or the residue," and then eliminate "where there are existing agreements requiring fixed arbitraries" in the last two lines.

Mr. A. S. Baldwin:—I wish the words, "that with existing crossings," in there. I do not want it to be so open.

Mr. Rhea:—There are other things besides existing crossings. It may be a junction, not necessarily a crossing, other things to interlock besides crossings. I think we might want to make it a little broader than that. Would "existing situations" suit you?

The President:—Does that meet your views, Mr. Baldwin?

Mr. A. S. Baldwin:—I think "existing situations" will cover it.

The President:—You have heard Mr. Rhea's motion, which has been duly seconded.

(Motion carried.)

Mr. Ewing:—I move the elimination of conclusion 3, and to insert in conclusion 2 the words "and operating" after the word "maintenance" in the second line of conclusion 2.

Mr. L. C. Fritch:—I am opposed to that motion, for the reason that conclusion 3 covers one of the difficulties that we have in interlocking contracts. The strong line may have a necessity for additional men in the tower, and that amendment will burden the weak line with that expense, which I think is unfair. A contract that is not fair should not be made. It seems to me that it is a protection to the weak line.

Mr. Ewing:—An advantage, as I see it, of an interlocking plant to any road is the proportion of operated-units, credited as exclusive benefits, to that railroad. If we are forced at any time to put in a junction or a crossing against our will, it would be a distinct hardship to require us to pay one-half the cost of the operation of that crossing or junction, when we are deriving absolutely no benefit from

it. If we are deriving benefit from a crossing or junction, according to the agreement we are required to bear our proportion of the maintenance, construction, etc., of that crossing, based on the advantages we get, so that to my mind it is very necessary that we should allow the operating cost to follow in the line of the direct benefit that we get.

Mr. L. C. Fritch:—I do not believe that this Association should lay down principles that cannot be deviated from. Now, any new contract for an interlocking plant, crossing another railroad, involving an interlocking plant, is a matter of negotiation, and the old road usually makes the best arrangement it can. Sometimes the law lays down what procedure shall be followed. But in this particular case, coming to the point of conclusion 3, you may have a case where in an interlocking tower an operator is required by one of the roads and not by the other, and it seems to me that this clause exactly covers that point and is very essential.

Mr. Rhea:—I will read from the report of the Committee:

"Your Committee has endeavored to eliminate the relations of its members to their respective employing companies and to consider the subject as they would if employed as experts. Assuming such a position, no doubt many bases of division might be given an argumentative hearing, but the test which we have considered as conclusive is as follows: The responsibility of all carriers in safeguarding and expediting traffic."

We do not want to take a narrow view on this proposition. Other public carriers have rights as well as those of the companies which we are representing. There is a broader principle than the one of immediate policy involved in this division. The other fellow could not cross our track at grade if the laws did not permit him, and the other man has rights to build his railroad, the same as we had when our railroad was built; so that the Committee think they have taken a position which this Association can with dignity and with equity appear before any railroad tribunal in the United States, or any other country, as to the fairness of its position. We all have our responsibilities, as is stated in the report, in safeguarding and expediting traffic.

Our reason for dividing operating expenses on a different basis than construction expenses is that the real equity of each situation is that each man pays for what he really gets. We, as a Committee, did not believe that the division of operating expenses on an operated-unit basis can be defended as fair from any point of view. That certainly is my personal belief, and I have had about twelve and a half years' experience in negotiating agreements, and during that time I knew of a good many different arrangements being tried as to the division of operating expenses, and then later, following these agreements out in their working, I have been satisfied for quite awhile that the fair and equitable way of dividing operating expenses is as to the number of

parties interested irrespective of operated-units or traffic. Your operated-units, both for construction, renewal and maintenance, are directly affected just as to what you get. That is a matter which you can control. You can increase or decrease. With operating expenses, you can have very little influence in trimming them. You will pay about so much to operate a situation whether you have 24 operated-units or 48 operated-units.

The paragraph in the latter part of conclusion 3 I think is eminently fair and I think is something which has provoked probably as much misunderstanding in interlocking situations throughout the country as any other one subject—one road trying to get the best of another, or get something for nothing, in plain English, and there have been a great many cases of that kind, and a great many cases where it has succeeded because agreements in some cases were worded purposely to take undue advantage.

The intention of this Committee is to put themselves in a position where they can appear before any railroad company as representing another, or that they can appear before any railroad tribunal, whatever it may be. I am perfectly satisfied to appear before any railroad tribunal in this country as to the fairness of this division of operating expense, because I firmly believe, from the years of experience I have had, it is a fair and equitable arrangement.

Mr. Ewing:—I entirely agree with what Mr. Rhea has said as to the division of costs on an operated-unit basis. We have a number of agreements on a lever basis, which is rather unfair, in view of the fact that some roads which want to be economical put three or four operated-units on one lever, when they should not be placed there, so that the operated-units, I agree, is a fair basis.

Now, as to a new junction, or new crossing, Mr. Rhea has said that we cannot prevent that, which is true. The new road has got to accept conditions as it finds them. The old road is there, the new one has got to cross the old road, or connect with it. It puts in an interlocking plant. The old road has not received any advantage at all. Now, what right have we got to say that they should pay one-half the cost of operating that plant? It seems to me that it is not a fair proposition.

Mr. A. S. Baldwin:—I quite agree with the view expressed by Mr. Ewing. When a new line is about to be built, the constructors of that line have ample opportunity of investigating what will probably be the necessary fixed charge in connection with its construction, and it should be part of the fixed charge that they should have to consider in contemplating construction. I see no reason why a new railroad should, as a general rule, be allowed to settle a fixed charge on another company that could not anticipate it. At the same time the conditions are so varied and the interests at stake differ so very materially, that I believe it to be inadvisable for this Association to try to lay down a definite, fixed rule to govern all cases, and, therefore, I

believe a motion to refer back this conclusion to the Committee should carry.

Mr. John R. Leighty (Missouri Pacific):—This rule will prevent the interlocking of the crossing of a trunk line by a spur line from another trunk line, because the owner of the spur would not be willing to pay one-half the operating expenses of the interlocking plant, and I fail to see why any distinction should be made between the maintenance and operation of the plant in the division of the expenses.

Mr. W. H. Elliott:—I would like to ask Mr. Rhea how he arrives at the conclusion that it is equitable for a railroad which is crossed by another railroad to be made to pay 50 per cent. of the operating expense—why should not the road which desires the crossing pay the entire expense of operation?

Mr. Rhea:—As I stated previously, it is assumed that existing roads will take care of this in negotiations of new contracts and make the best terms they can. I am free to say, from the discussion which has arisen, that we might have worded that conclusion somewhat differently to make our intent a little more explicit, as to what was suggested in conclusion 2—it is more particularly intended to cover existing situations. This Committee did not feel it was likely to very much influence future negotiations; it was to lay down a principle for a division of existing rather than future arrangements, but since that question is opened, I cannot but think if you will take a broad view of the matter, if you will look at the thing from the standpoint of public policy, when you say that the new road must assume all the obligations for expenses of crossings—the other man is building his railroad under the right of eminent domain, as the older railroad was previously built—the older railroad in its charter assumed obligations and these obligations are continued after its construction, as well as at the time it was built, and you have no right to take the position that you alone can do business and that the other man must be burdened, if he is so unfortunate as to come along later, by all these common expenses—I do not think that you can defend that viewpoint from the standpoint of public policy.

I am not representing public policy, but I think that in presenting a report of this character we have got to give due consideration to equity. The other men, as I have stated, have rights which we have got to recognize—carriers are endowed to do business and to assume certain responsibilities, and they have to assume certain obligations, and one of the obligations you assume when you take your charter is the obligation to permit other carriers to transact business and certainly to expedite and safeguard traffic.

Mr. W. H. Elliott:—In view of the explanation made by Mr. Rhea I would like to make an amendment to the motion before the house, that conclusion 3 be referred back to the Committee, to be reworded in accordance with Mr. Rhea's explanation.

In regard to the equity of the division of operating expenses whereby the initial road is required to pay a proportion of the operating expense, I do not agree with Mr. Rhea. A new road is obtaining facilities for which the existing road had to pay when it first bought its right-of-way, and the new road should pay the entire expense of operation of the interlocking plant required as a result of the crossing the same as it will pay for land, construction, etc.

In Iowa a law was passed that the old road should pay not only one-third of maintenance expenses, but one-third of cost of construction. This the roads brought before the courts and it was decided that the initial road would have to pay the entire expense of construction, but I believe it is still the law that one-third of the operating expense is paid by the older road.

Mr. M. L. Byers (Missouri Pacific):—It seems to me that the first sentence of conclusion 3 is leading us into some pretty deep water, and I would offer this amendment as a compromise between the different views: That the first sentence of conclusion 3 be omitted; that the second sentence read: "Where operating expenses are increased beyond the primary operating expenses by facilities for the exclusive use of one party, such party for whose benefit such facilities are provided should pay the entire additional operating expense."

In other words, I would suggest that we do not pass on this point on which we do not seem to be able to agree as to the proper policy, or as to its effect on us from other points of view.

The President:—For the benefit of members who have come in since this discussion commenced, the chair will repeat that this discussion is entirely for the information of the Committee and not for embodiment at the present time in the Manual.

Mr. W. C. Cushing (Pennsylvania Lines):—It seems to me that we can end this discussion if the Committee will say that these conclusions refer only to the class A agreements—that is the way I read the report, anyhow. I do not think this has anything to do with classes B and C at all, and that being the case the arguments that have been brought up are entirely foreign to the purpose. If the Committee says this refers only to class A, I do not think there is anything more to add.

Mr. Rhea:—Classes A and B probably.

Mr. John V. Hanna (Kansas City Terminal):—It has not been altogether clear to me what the Committee had in mind in primary operating expenses. The members, in the discussion, have all referred to operating expenses without any distinction. Will the Committee explain that a little?

Mr. Rhea:—By primary expenses we meant simply the expenses which would be involved in ordinarily operating an interlocking plant. If we put up an ordinary grade crossing or junction interlocking plant, with the standards of each road prevailing, it takes a certain definite amount of men and supplies to keep that interlocking plant in opera-

tion. Now, then, if you add a lot of block instruments or other apparatus, which require higher salaried men to operate them and more supplies, it seemed to us that it is thoroughly clear that the company getting the benefit of that should pay above what we have termed the primary expense, which means the ordinary expense incurred in operating the ordinary interlocking plant.

Mr. Hanna:—I agree with that thoroughly, but I would like to suggest that the Committee might, in working over this report, in drawing their conclusions, find some way of making that more explicit, so that any one who picked up the conclusions and read them would know what they had in mind.

The President:—Mr. Ewing's motion is before the house. Mr. Byers' motion was not seconded. Mr. Ewing's motion is to refer conclusion 3 back to the Committee for further consideration, and insert the words "and operating" immediately after the word "maintenance" in the second line of conclusion 2.

(Motion lost.)

Mr. Rhea:—I move the adoption of conclusion 3 as it stands, with the understanding that it particularly applies to existing situations. This is for the information of the Committee, and that is the point we would like to have information on, as to existing situations.

Mr. G. A. Mountain (Canadian Railway Company):—I have much pleasure in seconding that. I would go further and say not only present conditions, but future conditions. It seems to me where the junior road, as it is commonly called, crosses the single track of a senior road, and that road afterwards puts four tracks down and adds additional appliances, it does not seem to me fair or equitable that the junior road should be saddled with it. I agree with the views of the Committee, but go further.

Mr. Chas. S. Churchill (Norfolk & Western):—I trust that conclusion will not be adopted, as it will do injustice to many roads. It conflicts with State laws in many States, and there are cases where traffic must be taken into account, irrespective of what the Committee has said. We have made a number of settlements of that kind ourselves, and if we had not taken traffic into account we would not have had any interlocking plant at all. There are cases where a small road crosses a large road which does twenty times the business of the small road. If we insist that the small road shall pay one-half the expense of the interlocking plant, then we might as well give up the idea of having any interlocking plant at that crossing.

There are so many features involved in the adoption of the paragraph and so many conflicts will be raised in consequence of it if it is approved that we will make a great mistake if we adopt it at this meeting.

Mr. Wendt:—I move to amend the motion by striking out all words after the word "moved" and substitute the following: That con-

clusion 3 be referred back to the Committee for revision in the light of the discussion of to-day.

Mr. Rhea:—As a member of the Committee I must say that we will be left a good deal in the dark as to what the conclusions are. I do not see how, as a Committee, with the task assigned us to continue, we will not be able to make any progress. We will simply have to come back next year to have it settled.

Mr. Rudd:—I hope that motion will not prevail. It is simply referring back to the Committee, saying: "You made this report this year; take it back and guess again next year." Why not vote this down and then vote for or against the original motion? Give the Committee a chance to know how you feel about it.

Mr. Wendt:—The strong reason for referring this conclusion back is that a conventoin is not the best body to endeavor to rewrite a conclusion. The Committee itself should revise a conclusion, and the discussion of this morning indicates that there is no general agreement with respect to this question. The discussion even indicates that it is difficult to revise the wording so that it would be agreeable to the convention as a whole, and the Committee will be in no different relation to its work with the passage of the resolution than it would otherwise, as no final vote is being taken with respect to this matter. It is a question that relates entirely to a report of progress for the information of the Association, and the Committee is in the same strong position to consider the question and make its recommendation from whatever standpoint it thinks best in view of the general discussion of the morning.

Mr. C. P. Howard (Lake Shore & Michigan Southern):—It seems to me that this Association would be going rather far to attempt to pass on the question of adjusting the cost of constructing or operating any crossing plant. The legislatures, courts and judges fix the proportion of the operating expenses at crossings. It was suggested by Mr. Elliott, I believe, that when one railroad crosses another the new railroad should bear the whole charges; others maintain that they should be divided equally; but assuming that the cost of maintaining and operating interlocking plants are borne equally by the different railroads, we might take a case in which the total cost of operating and maintaining a plant is capitalized at $100,000; a new railroad would figure that its proportion of the cost of maintaining and operating that plant would be $50,000. If they could prove to themselves that the cost of an overhead crossing would be $60,000, of course, as far as they are concerned, they would be justified in putting in an interlocking plant, the total cost of which, capitalized, would be $100,000. It seems to me that it is no part of engineering to pass on the equity and justice in this matter; that it is a question of public policy; and that all this Association could do would be to indicate the basis on which the expense of the interlocking plant could be figured; that the cost of operation may be calculated on the basis of the number of operating

units, but it is no part of our business to indicate how much of this cost should be borne by one company and how much by another. I think we should keep clear of that.

Mr. Rhea:—If the last speaker's assumptions are correct, this Committee is woefully wrong in its position. We have assumed, in canvassing the laws and decisions of the various railroad commissions of the country, that there is actually need of an expert opinion on this subject, and I think a perusal of the different laws and a canvass of the decisions which have been made will bear our statement out that it is a pretty mixed-up situation as matters now prevail.

I have been called before the railroad commissions of some half dozen States, and I am familiar with many of the laws, and know that there is certainly much variance in the laws in the different States, and I believe I can make the statement with truth that the railroad commissions are looking for expert advice on the subject as to what is a proper division of this expense, and we, as a Committee, felt that in treating this subject as we did, we were carrying out the will of the Association in presenting a report which did deal with that part of the question.

If we are not as an Association capable of passing upon what is a proper technical and equitable division of construction, maintenance, renewal and operating expenses, I am rather at a loss to know what Association or what class of experts could determine such a question. I have been asked by members of railroad commissions of some of the States to express to them my opinion as to what should be done in particular cases, particularly where prevailing agreements were in existence, and without disrespect to our railroad commissions, I will say they certainly are not very fully informed on such matters, and they naturally have to look to expert opinion for advice on these subjects, and I took it for granted that an expression of opinion from this Association would be of value and would be a guide to these men as well as to the railroads proper.

Mr. C. P. Howard:—I think, then, that being the case, that this Association should go rather slowly in expressing an opinion. It is an extremely important thing, and, very likely, the members of this Association have not had time to consider all the bearings of the subject. It is a matter, of course, concerning which different State legislatures have made laws, and the question has been pretty fully discussed as a matter of public policy, as to how new railroads shall be favored, and as to what rights of property an existing railroad has, and I think it would be certainly wise to leave this subject in the hands of the Committee for further consideration, so that it can be looked into more thoroughly and all the aspects of the subject canvassed. I do not think all of us thoroughly realize the importance and seriousness of the question.

Mr. Rhea:—I think that is quite true, and believe this is a subject which should be handled with great conservatism, but I should like to

answer a little further that I feel a somewhat narrow view has been taken of this proposition. I rather gathered from what was said a little while ago that it was thought I was representing a particular railroad system in this matter. I am in a position at this time to take a broad view of this subject. This is my personal opinion. I am not representing the policy of any railroad to-day, but I think the practice is a little bit prevalent of taking advantage for our particular companies instead of the broader view. Now, answering Mr. Ewing's point: If this proposition is voted down it will go to a division of expense on an operated-unit. Mr. Ewing, as representing the Philadelphia & Reading Railroad, is not interested in his presentation of the case as best conserving the interest of his company, from the fact that his road is practically a four-track railroad; but he has not stated which units he wants the other road to pay for, the units on his railroad or the units on the other road. If he pays for the units on his own railroad, he will certainly get a burden, from an operating point, that is not fair. The old railroad will get the worst of the bargain a whole lot.

(Vice-President Snow in the chair.)

The Vice-President:—The motion is to refer conclusion 3 back to the Committee.

(Motion carried.)

Mr. Rudd:—That cleans up subject No. 4. Before proceeding to subject No. 5 I am requested by the Committee to move, that, in view of the action of the Association this morning, the specifications for mechanical interlocking, as we now have them, be omitted from the Manual which will be printed this year, with a note stating that the subject of mechanical specifications is still under consideration.

(Motion carried.)

Mr. Rudd:—In relation to subject No. 5, the Committee, as you will note from the report, has had a number of meetings, but has not yet arrived at anything definite. We submit the report shown on pages 338-340, the subject being "Comprehensive System of Uniform Signaling Suitable for General Adoption," as a progress report. I move its adoption.

Mr. B. H. Mann (Missouri Pacific):—I would ask the Committee just what we shall understand as to the adoption of this report of progress, particularly as to whether this vote carries the features outlined in the report. When the primary aspects have been adopted, does it mean that the secondary aspects are still open for discussion, or does it mean that both the primary and secondary aspects are still open?

Mr. Rudd:—As I understand it, the acceptance of the report as a progress report would not commit the Association in any way. That is how I intended the motion.

(Motion carried.)

Mr. Rudd:—Subject No. 6, relating to switchstands, is reported

on page 230. It was handled by sub-committee C, of which Mr. Mock was chairman.

Mr. Rudd:—In regard to subject No. 8, Symbols, that subject was handled by sub-committee E, of which Mr. Peabody was chairman. The report of this sub-committee appears on page 230.

The only change in the Manual will be the printing of specifications for insulated wire, the mechanical specifications having been eliminated and the power interlocking specifications having been accepted only as a progress report. I move the adoption of the report.

(Motion carried.)

Mr. Rudd:—In regard to subject No. 8, Symbols, that subject was handled by sub-committee E, of which Mr. Peabody was chairman. The brief report of the Committee appears on page 231. I move the adoption of the Committee as a progress report.

(Motion carried.)

Mr. L. C. Fritch:—Before the Committee is discharged, I think this convention should extend to it the thanks of the convention for its excellent work. It presented a report of 166 pages of very valuable matter, and I think a vote of thanks should be extended to this Committee.

(Motion carried.)

Mr. Rudd:—In behalf of the Committee, I wish to thank the Association and say if our report has given them any pleasure we will be glad to prepare a report with twice as many pages next year.

PRELIMINARY REPORT OF SPECIAL COMMITTEE ON INJURY TO SIGNAL EQUIPMENT, BRIDGES AND TRACK DUE TO BRINE DRIPPINGS FROM REFRIGERATOR CARS.

(Bulletin 106.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Special Committee appointed to report on "*The injury to signal equipment, bridges and track duc to brine drippings from refrigerator cars,*" held a meeting in Chicago September 4, all members being present, as follows: J. C. Mock, Chairman; C. H. Cartlidge and C. B. Hoyt.

The purpose of the meeting above mentioned was to go over such data as had already been collected relating to the subject, it having been previously agreed by correspondence that the preliminary work, and before any conference with the Master Car Builders' Association be attempted, should be directed toward collecting statistics on the extra cost to the Maintenance of Way Departments of railroads of the country handling refrigerator commodities, resulting from the present practice of allowing brine from refrigerator cars to drip on or just outside the rails.

That this practice is a factor in the maintenance of way costs is a fact already established, although your Special Committee has not had sufficient time to gather data from which a correct estimate of the aggregate annual expense to all the railroads due to brine drippings could be deduced. Enough has been learned to demonstrate that the question is one of the most important before the Association. The expense due to the shortened life of rails and fastenings, bridges and signal equipment, and the attendant expense because of more frequent inspections required and delays to trains on account of signal failures is difficult to express accurately, and any figures must therefore be regarded as approximate only.

As early as 1897, the Master Car Builders' Association received a report on this subject. The report states that the question was first brought to the public attention in 1896. From the report we extract as follows:

"The fact that the Master Car Builders' Association has thought it necessary to appoint a committee to prepare a report on this subject is sufficient answer to the claims of the owners of refrigerator cars that the salt water drippings are not harmful. . . . . .

"In such cars the mixture used for cooling purposes is composed of ice and salt, the proportion of the salt to the ice varying from 6 per cent. to 11 per cent., and one refrigerator car will produce about 200 gallons of salt water or brine every twenty-four hours, which on an average will contain 8½ per cent. of salt.

"At one icing station where 5,200 cars were taken care of, that number of cars was supplied with 6,072,000 lbs. of ice, and 503,000 lbs. of salt.

"Replies to the circular of inquiry sent out on November 22, 1897, have been received from railroads that handle about 55,000 refrigerator cars loaded with dressed beef per annum.

"The committee started out with the idea of having refrigerator cars fitted with one or more reservoirs, to be attached underneath the car body, into which the salt water drippings could be conveyed, the reservoirs to be large enough so that they would not have to be emptied more than once every twelve hours, at division terminals, where proper provision could be made for taking care of the salt water. This idea, however, met with so much opposition on the part of the refrigerator car owners that the committee abandoned it, not caring to recommend an arrangement that the refrigerator car owners would be unwilling to adopt.

"The committee presents two methods that can be followed without much expense, either one of which will improve the present condition of affairs; and although a patent has been applied for in the case of Design No. 2, it is the opinion of the committee that Design No. 2 will give the better results. Design No. 2 will be the more expensive, but it will not cost to exceed $5.00 per car, including a royalty, if the patent is granted. The principle of both designs is to convey the salt water so that it will drop between the rails at about the center of the track, where it will do little or no damage."

The following is an extract from a report to the Association of Railway Superintendents of Bridges and Buildings in 1898, on the care of iron bridges after erection, including the best method of protecting them from salt water drippings from refrigerator cars:

"The question of best method of protecting bridges from injury by salt water drippings is one upon which little can be said. That this dripping is very injurious to metal none will question, except, perhaps, the owners of the refrigerator cars. Some little interest is being taken in this subject by the officials in charge of track and bridges, but little or none by those in charge of the transportation department, and while the remedy should be applied to the cars instead of the bridges, there will undoubtedly be opposition to this method by the car owners, who will probably be very slow to provide their cars with the necessary protection unless forced to do so by the railroad companies' united action. One refrigerator car will produce probably 200 gallons of brine every twenty-four hours, which is distributed over the roadbed and bridges as the car passes along or is held on a siding. The damage is greatest when the cars are not in motion and on curves where slow speed is maintained. In order to protect bridges in such places it would be necessary to completely cover their decks with a waterproof protection with gutters to carry off the brine. This is ren-

dered necessary because the vents in the present refrigerator cars vary in their positions, thereby making it impossible to construct a single gutter to catch the flow. It has been suggested that attachments be made to all cars in such a manner that the flow of brine will always fall in the center between the rails. This will furnish considerable relief and in places where the flow is excessive, provision could be made to catch this flow and conduct it away from the metal work. The attachment to the cars would probably cost not to exceed $5.00 each, and would be a compromise between the railroad companies on the one side, providing a waterproof decking for the structures mostly damaged, and the owners of the cars on the other side, providing reservoirs to hold this dripping until discharged at regular stations."

Previous to this, it was well known to Signal Engineers and those having to do with the maintenance and operation of automatic signals that the drippings from refrigerator cars very seriously affected the operation of signals in wet weather (the heavy summer showers gave certain relief because of the tendency to flush the rail and rail fastenings). In 1901 the subject was mentioned in the Railway Signal Association in connection with a discussion on the maintenance of track circuits.

The Michigan Central Railroad was at that time experiencing so much trouble because of brine drippings that on certain troublesome sections they resorted to the use of oil on the rails. While this eliminated the signal failures, it was not a satisfactory solution of the problem from a financial standpoint, as the cost of oiling one mile of track per annum was in the neighborhood of $100.00.

In 1907, at the seventeenth convention of the Association of Railway Superintendents of Bridges and Buildings, the subject was again discussed under the heading, "Recent Experiments in Protecting Steel Railroad Bridges Against the Action of Brine from the Refrigerator Cars;" and Past-President Johnston, at the ninth annual convention of this Association, called attention to this subject in the following remarks:

"For some years the attention of the maintenance engineers of many of our railroads has been drawn to the effect produced by salt brine drippings on the life of rail and joint fixtures, and on the durability of bridges and other like structures. This has caused much anxiety, and has led to substantial money loss. This is more especially true of those lines which in the nature of things are the natural avenues for moving commodities requiring refrigeration in transit. The dripping of salt brine from refrigerator cars on track and on bridge floors is no small factor in their deterioration. Efforts have been made in past years to bring about some modification in the construction of such special cars, so as to eliminate a great deal of this trouble, but it still continues. So long as it affected only the life of material and did not necessarily introduce an element affecting train operation, and on the score of a disinclination to impose what might be esteemed burdensome conditions on a certain class of traffic, this important matter has

in a sense been ignored. What impels me, at this time, to bring it forward is a reference in the Association's Bulletin 97 to an experience on the Delaware, Lackawanna & Western Railroad, arising from the effect of salt brine drippings on automatic block signal operation. This question is worthy of renewed consideration, and if upon careful inquiry by the proper committee it is found to have a material bearing upon safe operation, there should be an immediate effort to secure by co-operation, through the Master Car Builders' Association, a modification of the existing arrangements for discharging the salt brine."

The subject was discussed by the General Managers' Association of the Southeast at a meeting held at Atlanta, Ga., on January 16, 1908. A letter from the Cincinnati, New Orleans & Texas Pacific, reading as follows, introduced the topic:

"Steel rails and fastenings, iron and steel structures are greatly damaged by brine drippings from refrigerator cars handling meat shipments, which damage could be greatly reduced by arranging the drip pipes so that the brine will drop in the middle of the track instead of on or near the rails."

The discussion indicated that the suggested method was not a very satisfactory solution of the matter, and it seems to have been disposed of by them, for the present at least, by the statement that the general experience of the members seemed to be that the volume of traffic with brine drip in that territory was so small that the trouble did not constitute a grave problem.

From the foregoing, it will be noted that the subject has received no continuous or enthusiastic study by any railroad organization with a view of learning just what it costs, and with the exception of the Master Car Builders' report of 1907, no recommendations have been made that would really do much in the way of improving conditions. It appears that the only method that would effectually eliminate the trouble met with so much opposition on the part of the car owners that the Master Car Builders abandoned it before making a recommendation.

Mr. W. C. Cushing's article in the Railroad Gazette of June 5, 1908, contained some illustrations of the rapid deterioration of spikes and tie plates which is believed to be due largely to brine drippings. We have herewith shown a few illustrations of tie plates, rail joints, splice bars and a bridge member, none of which have been in service over five years and some less than two years. We have also obtained data from several railroads giving quite careful estimates on the extra cost to their Maintenance of Way Departments, due to brine drippings, which we submit below:

Chicago, Burlington & Quincy Railroad Company:

Bridges.—On lines not exposed to refrigerator traffic, the paint on bridges will last on the average four years and remain in good condition. On lines which are exposed to refrigerator traffic, the iron work on the stringers and floor beams of bridges begins to show "pitting"

when protected only by oil paint within a few months after being painted. The cost of cleaning and painting a floor system will average not less than 25 cents per linear foot of bridge. It has been found that certain paints will last about one year, so that the cost on account of brine is estimated at 25 cents per foot per year. There are 150,000 ft. of iron bridge exposed to refrigerator traffic on the system, so that the annual cost of brine drippings on bridges alone amounts to $37,500, which is interest on $750,000.

TRACK.—The deterioration of tie plates, angle bars and the rail itself on tracks exposed is, in a great many places, extremely marked. Angle bars have been reduced ⅛-in. at the edge of the lower flange and tie plates reduced so that nothing was left but the ribs which were pressed into the wood. This represents a deterioration during less than ten years, the original thickness of the plates being ⅜-in.

Michigan Central Railroad Company:

TRACK.—On 545 miles of main track, it is estimated that the loss in rails during their life is about 10 per cent., and the effect on bolts, spikes and tie plates, which require more frequent renewals than the same items on westbound track which is not affected by the brine drippings, is 50 per cent. On this basis we have the following figures chargeable to brine drippings:

Bolts	$ 9,800
Tie Plates	27,000
Spikes	8,000
Rails	12,700
Angle Bars	1,500
Labor	50,000

BRIDGES.—The Bridge Department estimates that the increased cost of painting and more rapid deterioration of bridges amounts to $25,000 per year.

To this is added $4,000 per year because of increased number of track sections, increased amount of battery and the cost of extra maintenance because of these increases, making a total yearly cost of $145,000, which is the interest on $2,900,000.

SIGNALS.—The Signal Department report details additional cost as follows:

Maintenance of 91 track sections of the eastbound track above the number of sections used on the westbound track	$ 455
1,000 cells of battery	1,700
Extra labor and attendance	100
Labor and material for more frequent bonding and adding third wire	1,000
Extra amount of labor and material for interlocking fittings, connections, cross pipes, etc.	350
Labor of cleaning tracks	395
Total	$4,000

Lake Shore & Michigan Southern Railroad Company:

The additional cost on account of brine drippings from refrigerator cars on track circuits is as follows: Toledo District, $301; Michigan District, $100; Eastern District, $85, making a total for added battery of $486. To this should be added the cost of additional maintenance. It has also been found that the fiber in insulated joints on the eastbound track requires renewal oftener than the westbound and the estimated cost on this account is $1,500 per year.

The few statements above quoted are representative of existing conditions wherever refrigerator traffic is handled, and indicate only a portion of the enormous total expense incurred by railroads handling this class of traffic in repairing damage to signal equipment, bridges and track due to brine drippings. In addition to the Maintenance of Way departments directly affected, there are a number of other items not easily obtainable because somewhat indeterminate; for example, (a) the additional cost for repairs and maintenance of rolling stock; (b) the cost of trains stopped at automatic signals that have failed to operate due to brine drippings; (c) the extra cost for the up-keep of interlocking apparatus, both mechanical and electrical; and the failures and consequent train delays on account of the reduction of the insulating resistances; (d) electrified sections of railroads, using third rail to furnish the current for traction, will find that drippings from refrigerator cars as now arranged will fall on the third rail. This will of course cause rapid deterioration of the rail and rail supports; it will reduce the insulation resistance between third rail and ground, and consequently add to the power station output, add to any electrolytic action that causes damage, and reduce the factor of safety provided for against accidents to persons working about the third rail.

CONCLUSION.

Your Special Committee is of the opinion that the damage to railroad equipment, and especially to Maintenance of Way equipment, and the failures of signaling and interlocking apparatus, caused by the present practice of allowing brine to drip from refrigerator cars en route is of such vital importance in operating costs as to call for immediate action on the part of this Association, and we recommend that this Association formally request the American Railway Association to take such action as will stop the dripping of brine.

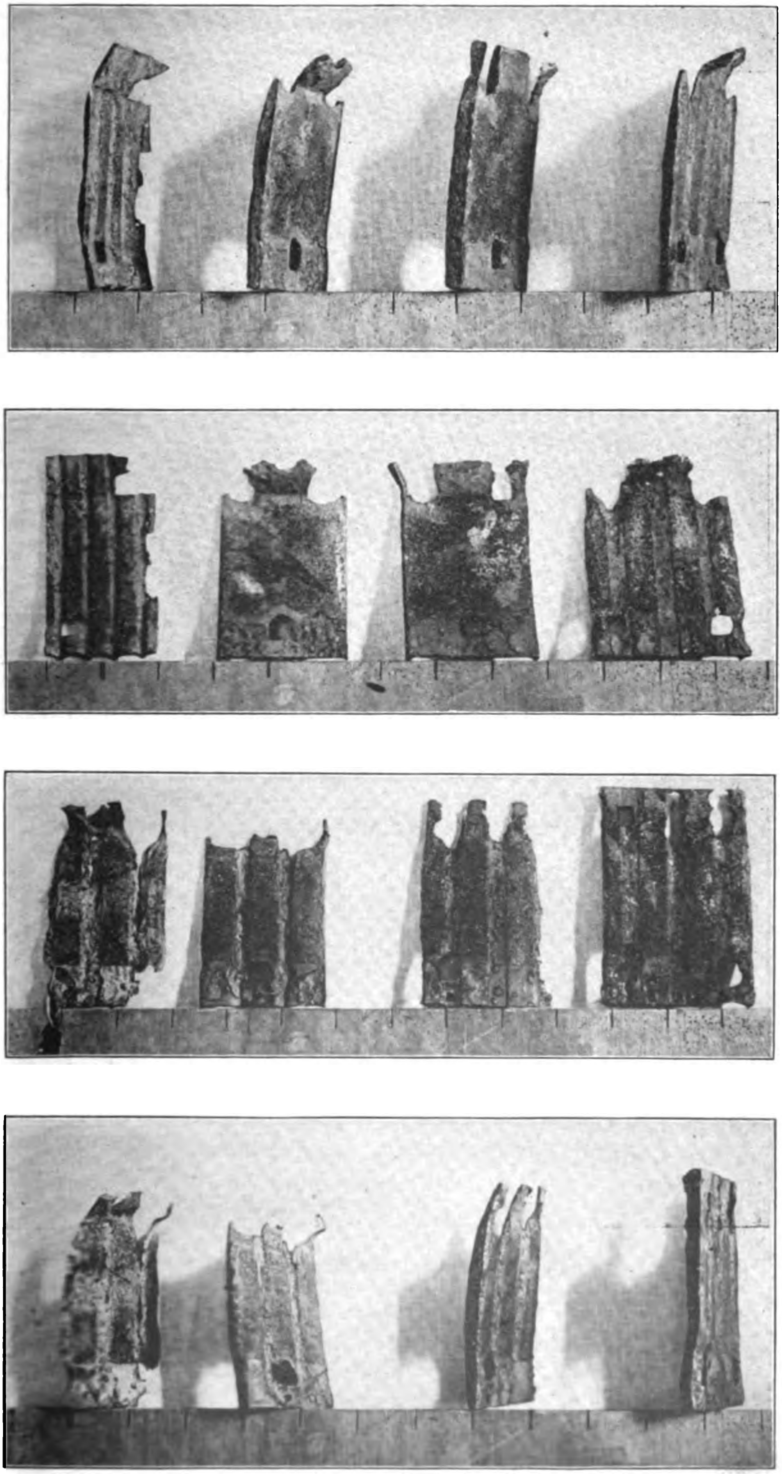
Respectfully submitted,

J. C. MOCK, Electrical Engineer, Michigan Central Railroad, Detroit, Mich. (*representing Committee on Signaling and Interlocking*), *Chairman.*

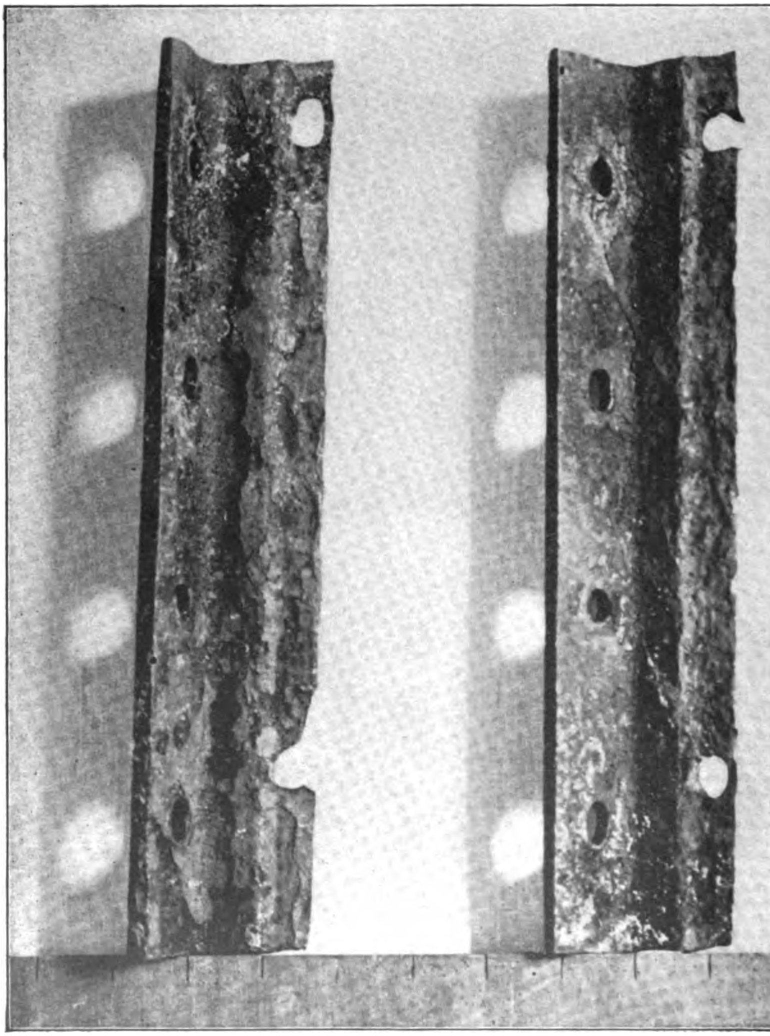
C. H. CARTLIDGE, Bridge Engineer, Chicago, Burlington & Quincy Railroad, Chicago, Ill. (*representing Committee on Iron and Steel Structures*).

C. B. HOYT, Superintendent of Track, New York, Chicago & St. Louis Railroad, Bellevue, Ohio (*representing Committee on Track*).

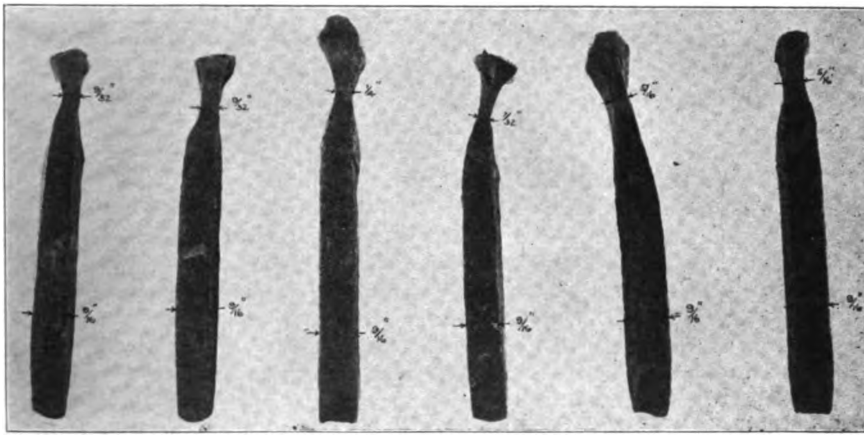
Special Committee.



VIEWS OF CORRODED TIE PLATES.

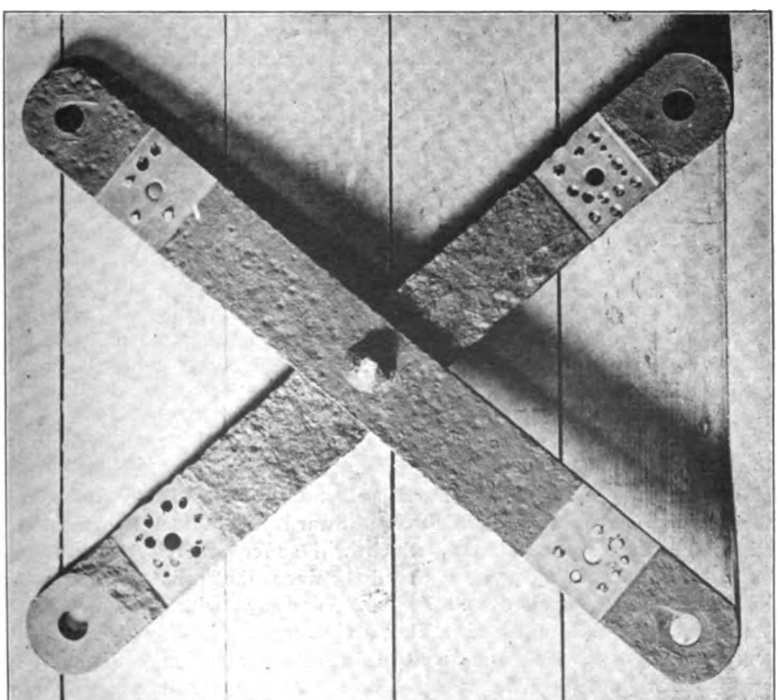


VIEWS OF CORRODED ANGLE BARS.



VIEWS OF CORRODED TRACK SPIKES.

(Track spikes removed from turnout rail between main track rails of eastbound passenger track; spikes placed in track July, 1906 (new), removed April, 1908.)



VIEWS OF CORRODED BRIDGE MEMBER.

DISCUSSION.

Mr. J. C. Mock (Michigan Central Railroad):—The report of your Special Committee on injury to Signal Equipment, Bridges and Track Due to Brine Drippings from Refrigerator Cars is given in Bulletin 106. The effect of brine drippings on signal apparatus has not been brought out as fully in this report as we hope to do in a future report, if it is found desirable to pursue the subject further, although we have presented some figures to indicate what it means to the Signal Department to continue the practice of permitting brine to drop from cars as at present. We submit for your approval the following conclusion:

"Your Special Committee is of the opinion that the damage to railroad equipment, and especially to Maintenance of Way equipment, and the failures of signaling and interlocking apparatus, caused by the present practice of allowing brine to drip from refrigerator cars en route, is of such vital importance in operating costs as to call for immediate action on the part of this Association, and we recommend that this Association formally request the American Railway Association to take such action as will stop the dripping of brine."

The Vice-President:—The gist of the conclusion is that we formally request the American Railway Association to take such action as will stop the dripping of brine. Are there any remarks?

Mr. L. C. Fritch (Illinois Central):—In lieu of the conclusion of the Committee, I offer the following resolution:

"*Resolved,* That the subject of brine drippings be referred to the American Railway Association with the recommendation that immediate action be taken to require that brine drippings shall be deposited in the center of the track in order to minimize the damage caused to Maintenance of Way structures by reason of the present method of disposing of such drippings."

Mr. F. E. Schall (Lehigh Valley):—I second the motion, but at the same time state that in my judgment carrying the brine drippings to the center of the track will not obviate the trouble. On the bridges the brine will be thrown toward the bottom flanges, tops and sides of floor beams, etc., which will suffer severely. Any track or signal appliances that are placed between the rails will also be injured. Some effective remedy to do away with the drippings entirely should be employed. The Maintenance of Way Department will be put to considerable expense to make provision to catch the brine in the center of the track, and it seems to me the remedy lies in something else. I think the remedy should be applied at the

root of the disease. Any member of the Association connected with an Eastern road knows the disastrous effect of the brine drippings. I know that the chairman himself has had ample experience on this score. I should prefer to see a more definite remedy suggested, something to take care of the brine in the cars.

Mr. G. J. Ray (Delaware, Lackawanna & Western):—I agree with what Mr. Schall says, that we should not take any half-way steps in the proposition. It is certainly a very serious thing with some of the Eastern roads—it certainly is in our case. I am in favor of taking some positive action, rather than a half-way remedy, for it is only a partial remedy if you put the brine in the center of the track. I think we should take some action to prevent the dripping of the brine from the cars at all, as in the case of signaling work, and also in the case of the rail, bolts, splice bars and bridge structures it is a serious proposition and an expensive matter, and becomes more expensive as we increase our better appliances in railroad work. As we become better equipped with signal appliances, this damage and trouble we are now experiencing will grow larger and larger, and it is a matter that should be referred to the American Railway Association with a request to take positive action.

Mr. W. G. Besler (Central Railroad of New Jersey):—The subject is one of wider scope than merely its relation to this Association, in that the cars and equipment are much affected by the salt brine drippings, as well as the track appliances. I have recently had correspondence with the chairman of the Southeastern General Managers' Association and the Chicago Association, all on the subject of this damage, not only to the track, but equipment itself, and I believe that the action proposed by the Committee to refer this matter to the executive committee of the American Railway Association and request that association to take care of the matter in delegating it to some sub-committee or some proper committee, is the proper action. This subject not only relates to the track, but to the cars themselves.

The Vice-President:—I ask Mr. Besler, as a representative of the American Railway Association, if he thinks the statistics gathered by our Committee would be of interest to the American Railway Association?

Mr. Besler:—Any committee assigned to cover this matter by the American Railway Association might use the data we have collected, as well as data collected on the subject by the M. C. B. Association, and other sources, all of which might be taken into account in any action they might conclude to take. It might be possible they would refer the question back to us for additional action or otherwise.

Mr. A. W. Johnston (New York, Chicago & St. Louis):—I heartily second what Mr. Besler says. While the motion offered by Mr. Fritch tends to relieve one particular feature of the trouble, it by no means removes the difficulty. Formerly, the old type of car

had a pipe toward the center of the track, and that was the beginning of the deterioration with which we now have trouble, and it seems to me the resolution offered by Mr. Fritch should not prevail, but that the Committee's conclusion be the basis of a reference of the whole question to the American Railway Association, to deal with as they see fit.

Mr. L. C. Fritch:—In defense of the resolution I will say that this matter has been under consideration for ten years. The M. C. B. Association has already recommended to the American Railway Association that this subject be considered. I was fully aware that this resolution did not contemplate the full removal of the evil, but in my opinion it will remove at least 75 per cent. Is it not better to get 75 per cent of the loaf, rather than to get no loaf at all? We all know dripping brine in the center of the track will affect bridges, but it will not affect track appliances except where there is a crossing or turnout. It will also not affect the wheels of cars. It seems to me, therefore, a practicable move which can be applied at not to exceed five dollars a car, which is more within our possibility of reaching, than to open the subject again for some method that will cure the entire evil.

I have never seen statistics before that brought this matter so vividly to my mind. When you consider that on one railroad $37,500 a year is estimated to be lost on account of this cause, what must it amount to on all the lines over the entire country? I am satisfied if this matter is referred to the American Railway Association it will result in serious delays very much as it did before.

Mr. C. H. Ewing (Philadelphia & Reading):—I believe we would be in better form, in going to the American Railway Association, if we did not tell that association how to cure this trouble. They will thresh the thing, through their committee, out for themselves, as suggested by Mr. Besler.

Mr. Mock:—I think I speak for the Committee when I say I think the remarks of Mr. Ewing are in line with what the Committee thought proper—not to recommend ways and means, because that is not in our province. The cure will have to be effected by the motive power departments of the railroads. We also felt that we should not recommend a half-way measure. The dripping of brine in the center of the track will but little relieve the signal situation, because the leakage is dependent upon the insulation resistance between the rails for the operation of the circuit, and on curves and superelevated portions of track we get it spread a good deal over the area between the rails. We have experienced a great deal of trouble, and I have no doubt a good many railroads who have handled this sort of traffic have similar difficulty. On many of our track circuits where we should operate 3,000 or 4,000 feet, we have to cut them down to 1,000 feet, resulting in more equipment and more liability to signal failures. The Committee believed that it

should present to you the question of cost, because the Signal Department can take care of the situation by sufficient outlay of money in material and men to take care of the signal operations. I have no doubt the Bridge Departments can do likewise, but we feel as it stands this recommendation should be referred to the American Railway Association without mentioning how it should be done, although we have indicated in our report about the only means that seems to be practicable; the stopping of it and not the mitigation of it is what we believe to be proper.

Mr. Schall:—I think the plan outlined by Mr. Besler is the best course. The American Railway Association will appoint a committee with sufficient members to investigate this matter for themselves. Such committee can go to the various roads affected and call for figures which they will probably take more interest in than if this Association furnished them. I think now is the time for action; the proper way would be to let Mr. Fritch modify his resolution, or to vote it down and adopt the Committee's recommendation and transmit it with the resolution that the Association recommends immediate action. I seconded Mr. Fritch's resolution to get it before the house, but I think the Committee's recommendation should be adopted.

(The amendment was lost; the Committee's conclusion was adopted.)

The Vice-President:—The Committee will be relieved with the thanks of the Association.

REPORT OF COMMITTEE NO. XIV—ON YARDS AND TERMINALS.

(Bulletin 106.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Yards and Terminals submits herewith its ninth annual report. As the instructions of the Board of Direction (upon which this report is based) are supplementary to those of last year, the work of the Committee has been concentrated mainly upon the development of two subjects previously considered:

(1) The operation of hump yards.

(2) The use of machinery for handling freight.

While the Committee is able to present considerable information as to these matters, it is not of such character as to enable general conclusions to be drawn or definite recommendations to be made. The Committee therefore presents this as a report of information. The detailed information as to methods of operating hump yards appears to form a fitting conclusion to the Committee's investigation of the design and operation of hump yards, which investigation has extended over some years.

THE OPERATION OF HUMP YARDS.

Your Committee is able to present valuable information as to the details of methods of operation employed at a number of freight yards of the gravity type. There is little opportunity, however, for generalizing or drawing conclusions, owing to the varying local conditions. The matter is therefore presented as an appendix in convenient form for the information of those engaged in the design or operation of freight yards. (Appendices A and B.)

Two separate inquiries were made by the Committee: First, as to the methods of operating hump yards (noted above); Second, as to the number of yards of this type in use or contemplated. From the replies to the latter series a table has been compiled showing 82 such yards in use. (Appendix C.)

It may be noted that there is a preponderance of opinion in favor of placing track scales on the hump. The location varies from 30 ft. to 300 ft. below the summit.

Some advantages of using two scales are also pointed out. They enable separate parallel tracks to be built for summer and winter conditions, and also allow the regular work to continue while one of the

scales is under repair. But two parallel humps cannot be used at one time in connection with one classification yard, and to provide an additional or alternate hump for use in emergencies entails a loss of room and distortions of lines in both. There is, therefore, a reasonable doubt as to the value of such installations. At principal gateways of movement, and at points of origin of large volumes of freight of mixed character, and wide distribution the classification should be made, (1) as to fast or slow movement, and (2) as to destination.

The question is presented therefore as to the relative merits of the alternative plan of providing a second classification yard with the second hump to be used for fast freight, thus making it possible to take either hump out of service for a limited time without causing complete stoppage of classification, and making it possible to nearly double the classification capacity with a comparatively small increase in facilities. The second hump might be parallel with or tandem with the first, according to local conditions.

The relation of the percentage or proportion of cars to be weighed to the location of scales on the hump or elsewhere is not yet determined. We have testimony to the effect that the scale should not be located on the hump unless about 25 per cent. of the cars to be handled must be weighed. We also have the opinions of men who are in charge of large hump yards that handle thousands of cars daily, that the scale should be located on the hump regardless of the number or proportion of cars to be weighed. We assume therefore that the greatest economy would be secured by locating the scale on the hump if it is assured that from 5 to 10 per cent. of the cars must be weighed.

In this connection, we present the following discussion of the subject, received from Mr. H. M. North, Engineer of Construction, Lake Shore & Michigan Southern Railway:

"A few suggestions are vividly before me because of difficulties that have attended the designing of certain terminals in my own experience. I would respectfully suggest that the Committee should give very careful attention to the question of the advisability of placing scales on humps, and that it should not come lightly to a decision in this matter. It is my full belief that there is no possible scheme of grades for a hump where a scale is placed within the hump limits which will enable traffic to be handled within 50 per cent. of the speed that can be secured at the same point if the scale is not placed on the hump. In practice the placing of scales on humps is invariably attended by embarrassment to the efficiency of the yard for non-weighing traffic, this embarrassment usually being unnecessarily great.

"In designing the Gould System yards for the St. Louis gateway, where the weigh traffic aggregated about half the total traffic passing through the terminal, I placed the scale on the hump of my own option and with the full approval of the very able operating and construction officials of that System. This decision was caused by the evidently

greater evil involved in placing the scales elsewhere. Like many other things in railway work, it was simply a matter of meeting a situation with the best solution of all questions involved, this solution involving admittedly and knowingly serious disadvantages in certain respects. Had the proportion of non-weigh freight aggregated 75 per cent. or so of the total traffic the scale would not have been placed on the hump at this terminal.

"Another question of considerable importance is the placing of a second track over the hump. Such a detail of design is certain to present itself to consideration in the study of yard work, it being manifest that derailment on a single throat track will entirely tie up the yard and that the ordinary maintenance work of renewal of rails, ties, fittings, etc., will also stop shifting work unless some emergency throat is constructed. In attempting to provide an emergency track of this kind I found it to be impossible to design one which would not unfortunately affect the grade arrangements so as to delay freight movements into the yard, and the matter resolved itself into abandoning the emergency throat track as involving greater injury than it was designed itself to prevent. It needs no discussion to point out the futility of trying to bring two bunches of cars simultaneously into a given yard by the use of two throat tracks. No competent operating man would undertake such method of handling cars, and this feature of the emergency throat track need not be considered.

"Another matter that is emphasized in my own experience is a provision at the outlet end of the classification yard for grouping together the different classes of cars to make up fast-freight trains at a speed which is sufficiently great to meet the demands of the operating department. This work I have thought could usually be done by tail switching at the outlet end of the classification yard, but in one case it has developed that a second hump must be introduced for this purpose. This particular item of work is an essential item in any yard and should be fully considered. It is sometimes lost sight of in yard design."

We have also the following remarks from Mr. Samuel Rockwell, Chief Engineer of the Lake Shore & Michigan Southern Railway, and details of the operation of the two yards mentioned are given in Appendix A:

"In connection with the New York Central Lines we have been figuring on a large hump yard near Buffalo, and the design for this yard has been a subject carefully considered by a committee selected from the operating and engineering departments of both roads extending over the best part of two years. The conclusions reached there, based largely upon the operation of the Elkhart and Collinwood yards, was that it would be necessary that more than 25 per cent. of all the cars which went over the hump needed to be weighed in order to justify putting a scale on the hump, and since, with the character of the

business which this yard would probably have to handle, there would not be nearly so large a proportion of weigh cars as this, it was decided that it would not be wise to put scales on that hump, and the plans are so made up."

It is probable that Mr. North is right as to the second scale and main track, but we cannot agree that the introduction of a scale in the main hump track diminishes the efficiency of the hump as a machine for classifying cars to the extent of 50 per cent. The chairman of this Committee knows that it is possible to classify and weigh cars at the rate of 300 cars per hour over one scale and one hump for a limited time, and that when cars are crowding the classification facilities the trouble is generally that the supply of men to handle the cars is inadequate rather than that the hump and scale are overtaxed.* (See the replies to questions Nos. 8 to 10 in Appendix A.)

There are very few railways with double track and mixed traffic that can handle trains of sufficient size to enable them to take care of this volume of business, and it is also true that very few roads have this volume of business to handle, or will have it to handle in the near future.

Therefore the question of loss of efficiency on account of the presence of a scale on a properly designed hump need not trouble us at present, and we need not begin to consider it until we can reasonably anticipate a possible movement in one direction exceeding 5,000 cars to be weighed and classified in 24 hours. It is believed that long before that time we will be using two separate yards, each with its hump and scale, one to be used for fast and the other for slow freight. This will overcome the trouble anticipated from overcrowding, but in another and better way, and still retaining the scale on the main hump track to be used whenever and to whatever extent it may be needed and without material loss of time or efficiency of the hump.

The suggestion made by Mr. North that this work can be done by tail switching at the outlet end of the classification yard is available

*A member of the Committee offers the suggestion that by using scales of higher capacity than are ordinarily required, with correspondingly greater length of bearings, the objection to running all cars over the scale might be greatly reduced, as it would be possible to avoid the use of a dead track and to place the scale very close to the summit of the hump.

The Committee stated in its report of 1907 that it is not advisable to run any cars over the scale that are not to be weighed, for the reason that the accuracy of the weights depends largely on the sharpness of the bearings. When the edges become dull the friction is increased, and more weight is required to overcome the inertia of the parts.

When the proportion of cars to be weighed is large (say approaching 50 per cent.) there would probably be some advantage in eliminating the dead track. By so doing the scale could be more advantageously placed, and the profile of the hump could be modified somewhat so as to slightly increase its capacity. But to do this it would be necessary to keep a stock of spare parts on hand, to be used to replace those with worn bearings as often as might be required. This would cause delay, because the classification would stop while the scale is out of service. The Committee has stated that the principal cause of delay in a classification yard is waiting for the return of car riders, and it is not probable that many cases will be found where any marked advantage would be secured by the elimination of the dead track over the scale. It is no doubt a question that should be considered in connection with the proportion of cars to be weighed.

only where the volume of fast freight is very small, otherwise the delays caused by this method of handling would prohibit its use.

Probably the most important matter for consideration in connection with the subject of prompt and economical handling of freight is proper classification as to character and destination. Therefore when high-class freight has been properly grouped it should not be again mixed with slow freight at a division terminal or point of divergence, but without mixing with freight of different character should be classified as to destination only in preparation for further movement.

We do not need to omit scales from humps on account of loss of efficiency caused by their installation, but we do need generally better yard design, steeper grades between the summit of humps and the receiving ends of the classification tracks, and better facilities for the return of car riders.

In hump yards in which the grade approaching the hump is heavy the cost of operation is excessive, because a large amount of power is required to get the cars to the summit. In some cases very large engines are used. In other cases two large engines are coupled, and in many cases trains that were hauled into the yard with one engine are cut into two or more sections to be pushed over the hump.

In some cases the lack of room has caused heavy grades approaching a hump, with consequent increase in cost of operation, and in many places where lack of room has prevented gravity classification, it could be successfully employed if the cars could be handled promptly on approach grades that are too heavy for operation by locomotives.

We present therefore as a suggestion the plans of works that have been in successful operation for many years in Pennsylvania for operating freight traffic over short routes with inclined planes (by cable) instead of over longer routes with ordinary grades by locomotives. These works are still used extensively, notwithstanding the fact that much time and study have been devoted to the problem of devising cheaper and more satisfactory methods. It will be observed that the operation is generally on double tracks, the cars being hauled up by a wire cable first on one track and then on the other. In some cases empty cars are lowered as a partial counterpoise, thereby making it possible to increase the load to that extent. (For description see Appendix D.)

It is thought that where more than one engine is required to push a train over the hump, or where the approach grades are too steep to be operated successfully or economically by locomotives, the question of substituting stationary power is worthy of consideration.

FREIGHT TRANSFER BY MOVABLE PLATFORMS.

We have been unable to obtain any further information on the subject of transferring freight by means of movable platforms, as no installations using this method are known to be in service. The only

information, therefore, is that already presented in our last report. This showed that the only actual application of the suggested system was the use of ordinary flat cars as an auxiliary or emergency measure at a transfer with fixed platforms.

TERMINAL FREIGHT HOUSES.

A plan and section of the Grant Street freight station (Pittsburg) of the Pennsylvania Lines are shown in Fig. 1. The building is 365x155 ft., and is two stories high. The method of handling freight is about as follows, from information furnished by Mr. W. C. Cushing:

The inbound freight is of two kinds, car loads and less than car loads. The former does not enter the house, the freight being delivered from cars to teams. The latter is set into the house during the night and in the forenoon, and is trucked from the cars to the elevators, of which there are four, of four tons capacity each. These elevators are hydraulic, with a speed of 20 ft. per minute, and are 10 by 16 ft. in size. The number of freight handlers employed is 17.

All of the inbound freight is taken to the upper floor in the ele-

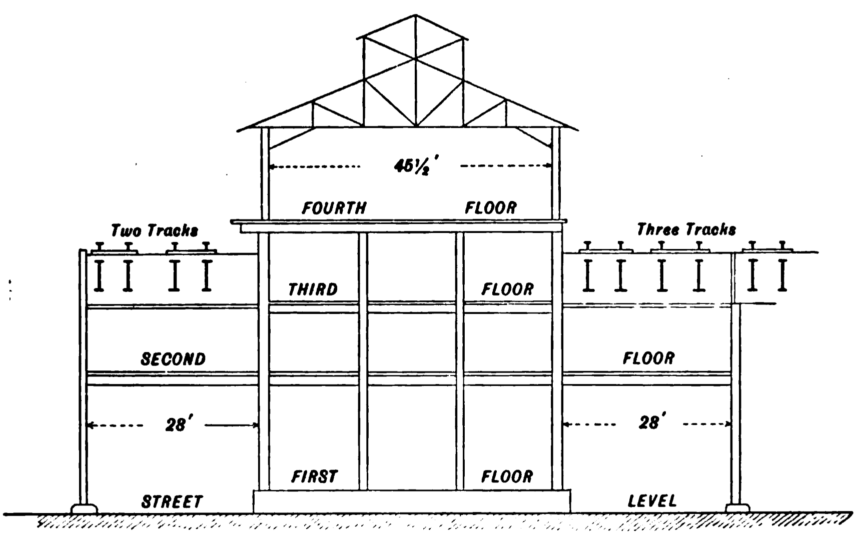


FIG. 2. FOUR-STORY FREIGHT STATION AND WAREHOUSE AT PITTSBURG; WABASH-PITTSBURG TERMINAL RY.

vators and delivered on that floor to the teams, the haul being all downhill. After the cars are empty, they are reloaded outbound from the platforms on the lower level, the teams delivering the freight to the platforms from the lower level driveway.

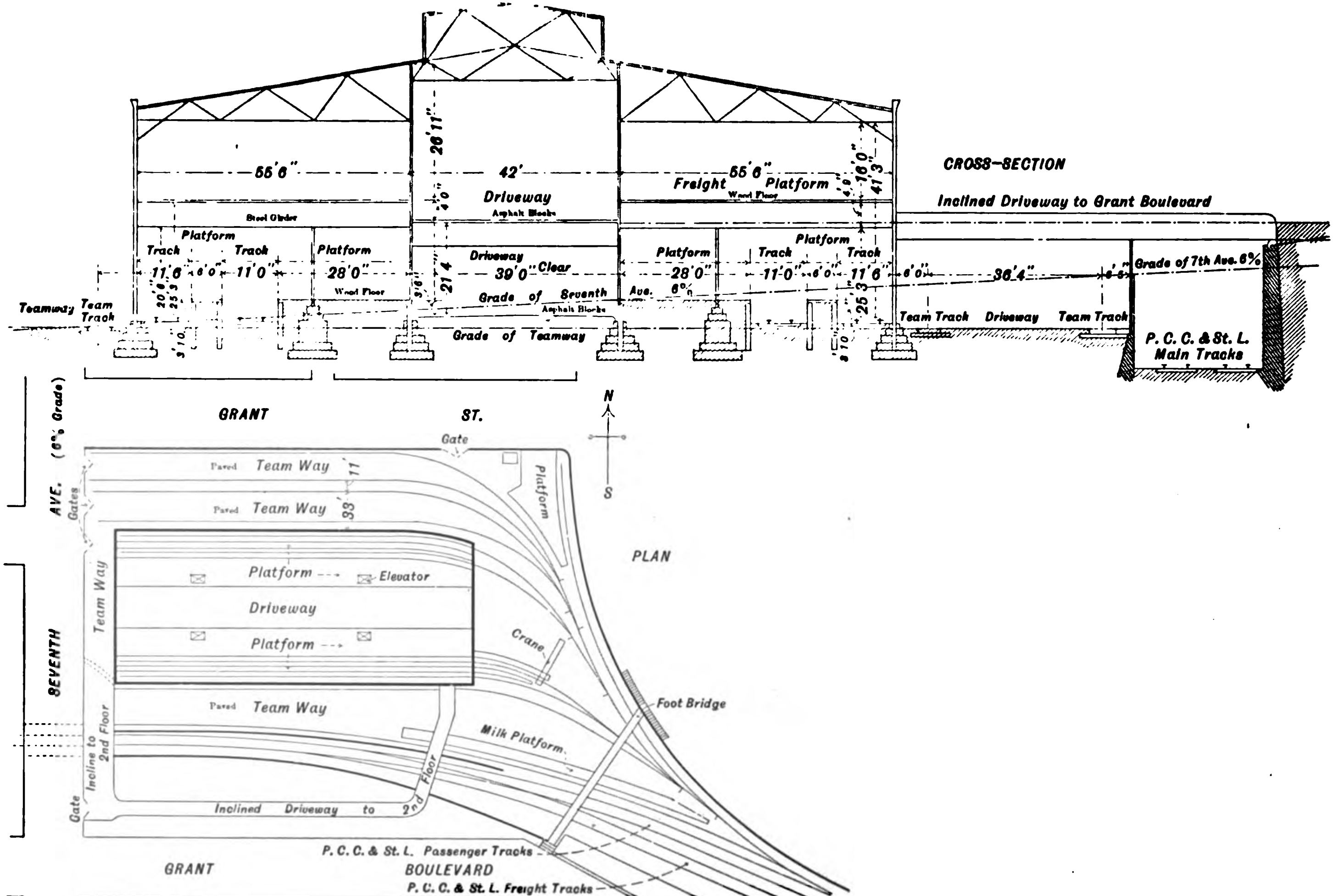


FIG. 1. PLAN AND SECTION OF THE GRANT STREET TWO-STORY FREIGHT STATION AT PITTSBURG; PENNSYLVANIA LINES.

The arrangement of the combined terminal freight station and warehouse of the Wabash-Pittsburg Terminal Railway is shown in Fig. 2. It is a four-story steel building about 60 ft. in width, with the team delivery on the first floor, and the tracks at the fourth floor level (about 60 ft. above the street). There are three tracks on one side and two tracks on the other side. The intermediate floors are used for storage and private warehouse purposes, as in the Newark and Pittsburg terminal warehouses described in the Committee's report of 1908. The building has one 10-ton plunger elevator and five 5-ton plunger elevators. Freight from the cars is loaded upon three-wheeled trucks. Four or five of these trucks are run upon an elevator and carried to the intermediate floors for storage, or to the bottom floor for delivery to wagons. Freight received by wagons is disposed of in the same way for delivery to storage or to cars. Thus intermediate handling of the freight is avoided. None of the cross streets are interfered with by this building, the freight house (or first floor portion) being interrupted to let the streets pass through.

At important points and large cities there is an increasing use of terminal freight stations having upper floors for warehouse and storage purposes. These are for handling freight in less-than-carload lots. Team tracks for car-load freight may then be provided on the surface in the manufacturing districts rather than in the business centers, where package freight is usually handled. This arrangement for such localities may, as a rule, give material economic advantages over the ordinary one-story building. In the latter it is difficult to avoid an excessive amount of trucking over long horizontal distances, as noted later in regard to freight handling machinery. But with a building having upper floors, much of the movement must be effected by elevators, and the movement can be effected rapidly and economically by means of an ample number of elevators.

A two-story freight transfer house might be found economical in certain cases, owing to the use of elevators and the saving in ground area. All freight to be transferred would be elevated and then trucked over an unobstructed floor to the elevators feeding the cars into which the freight is to be placed.

The one-story terminal freight house is the type in most general use, and some modern arrangements are here illustrated. In Fig. 3 is the cross-section of the terminal freight house of the Missouri Pacific Railway at the State Line Yards in Kansas City. There is one trucking platform, with three tracks between this and the inbound house, and four tracks between it and the outbound house. The general plans of the Pennsylvania Lines freight and transfer house at Columbus, Ohio, and freight house at Indianapolis, Ind., are shown in Figs. 4 and 5. The length and car capacity of the tracks of the Indianapolis freight house are as follows:

Track No.	Track Length, ft.	Car Capacity.	Track No.	Track Length, ft.	Car Capacity.
1	270	7	9	210	5
2	220	5	10	180	4
3	230	6	11	200	5
4	220	5	12	170	4
5	230	6	13	180	4
6	210	5	14	170	4
7	220	5	15	180	4
8	200	5	16	190	4

Total length, 3,280 ft. Total car capacity, 78 cars.

With reference to the general arrangement of buildings and platforms and the track layout of freight terminals, Mr. Rockwell, Chief Engineer of the Lake Shore & Michigan Southern Railway, submits plans of the recent freight layout on the Middle Ground at Toledo. These are shown in Figs. 6 and 7.

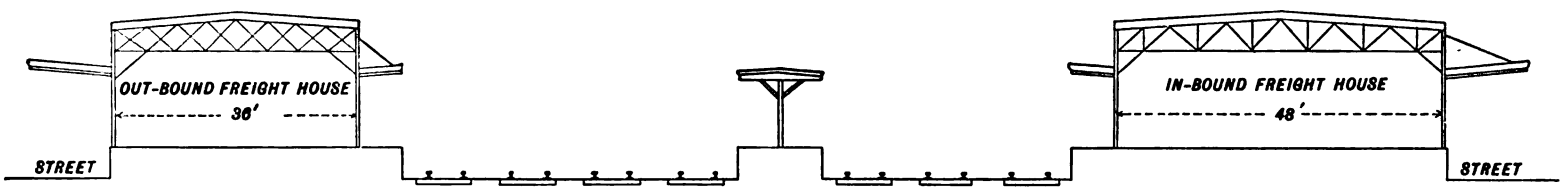
The result obtained with this layout is about as follows: In the old house, which this supersedes, 29 gangs of six men each handled 200 cars in 24 hours at a cost of about 45 cents per ton. In the present houses, the same amount of work is done with 17 gangs of six men each at a cost of about 35 cents per ton. It is estimated that when business increases sufficiently so that there will need to be handled 400 cars in 24 hours, it can readily be done with 30 gangs at a cost of not to exceed 30 cents per ton.

Particulars of a large modern freight terminal station on a British railway, with a large equipment of freight handling cranes, are given in Appendix E.

FREIGHT HANDLING AND CONVEYING MACHINERY.

Your Committee's inquiries in this direction have been mainly barren of practical results, and there appear to be no conveyors in use in ordinary freight houses. Inquiries sent to a large number of manufacturers of machinery of this kind have failed to bring to light a single installation, although several state that their machinery is applicable to the service. In a few cases, conveyors are used for loading and unloading cars at industrial establishments and at steamship piers. This latter case was considered in our 1908 report.

For handling heavy or bulky freight at yards, cranes are very generally used. These may be fixed jib cranes, or overhead cranes of different classes. The latter usually span one or more tracks and a driveway, so as to transfer the articles between cars and wagons. These may be classed as follows, the bridge in each case carrying a trolley hoist which travels upon it: (1) the bridge fixed; (2) the bridge traveling on an elevated runway; (3) the bridge carried by towers, which travel on surface tracks.



Track centers 12 ft. apart, 6 ft. from edge of platforms. Side platforms 6 ft. wide: middle platform 12 ft:

FIG. 3. SECTION OF FREIGHT STATION AT KANSAS CITY; MISSOURI PACIFIC RY.

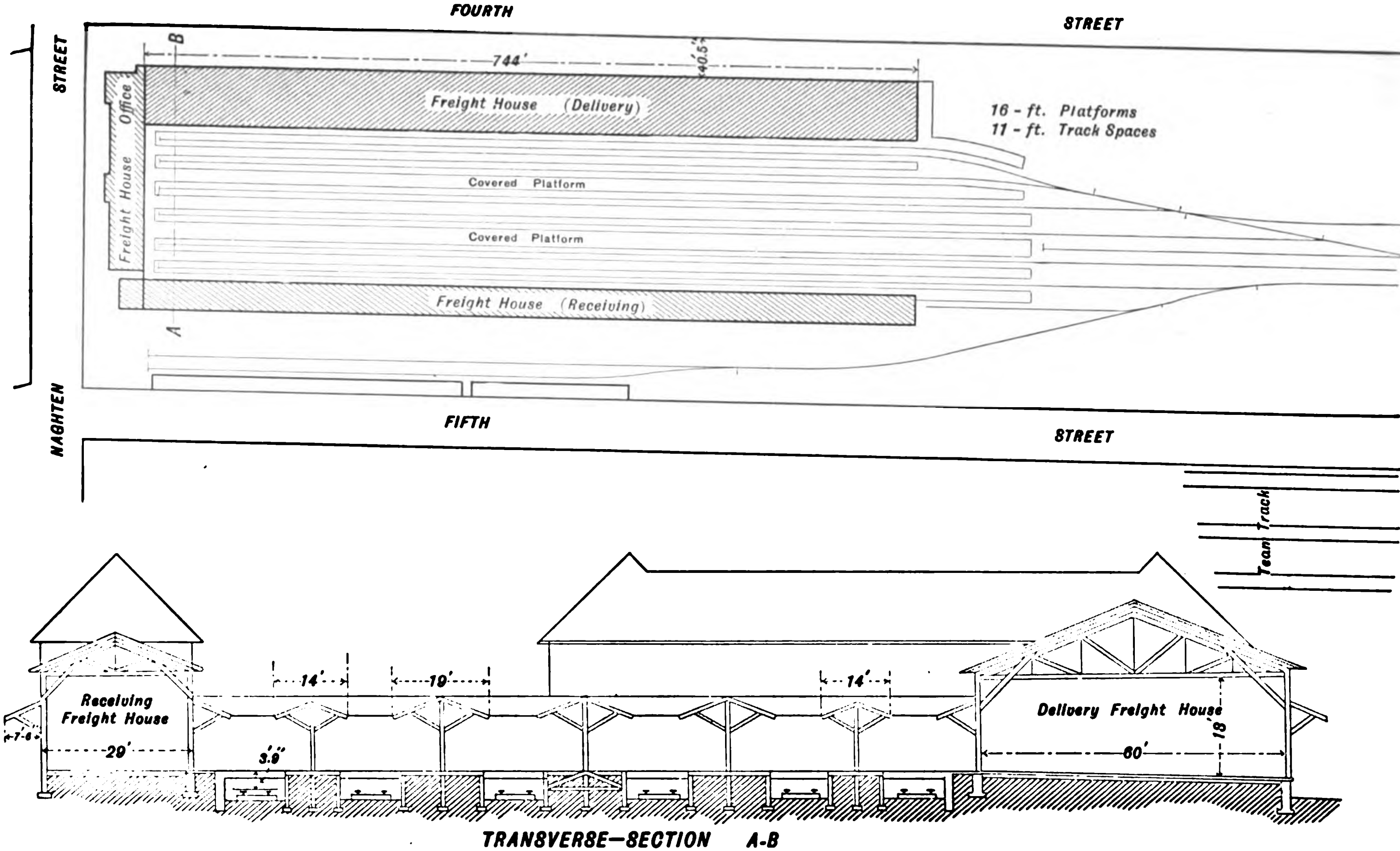


FIG. 4. PLAN AND SECTION OF THE FREIGHT AND TRANSFER STATION AT COLUMBUS, O.; P., C., C. & ST. L. RY.

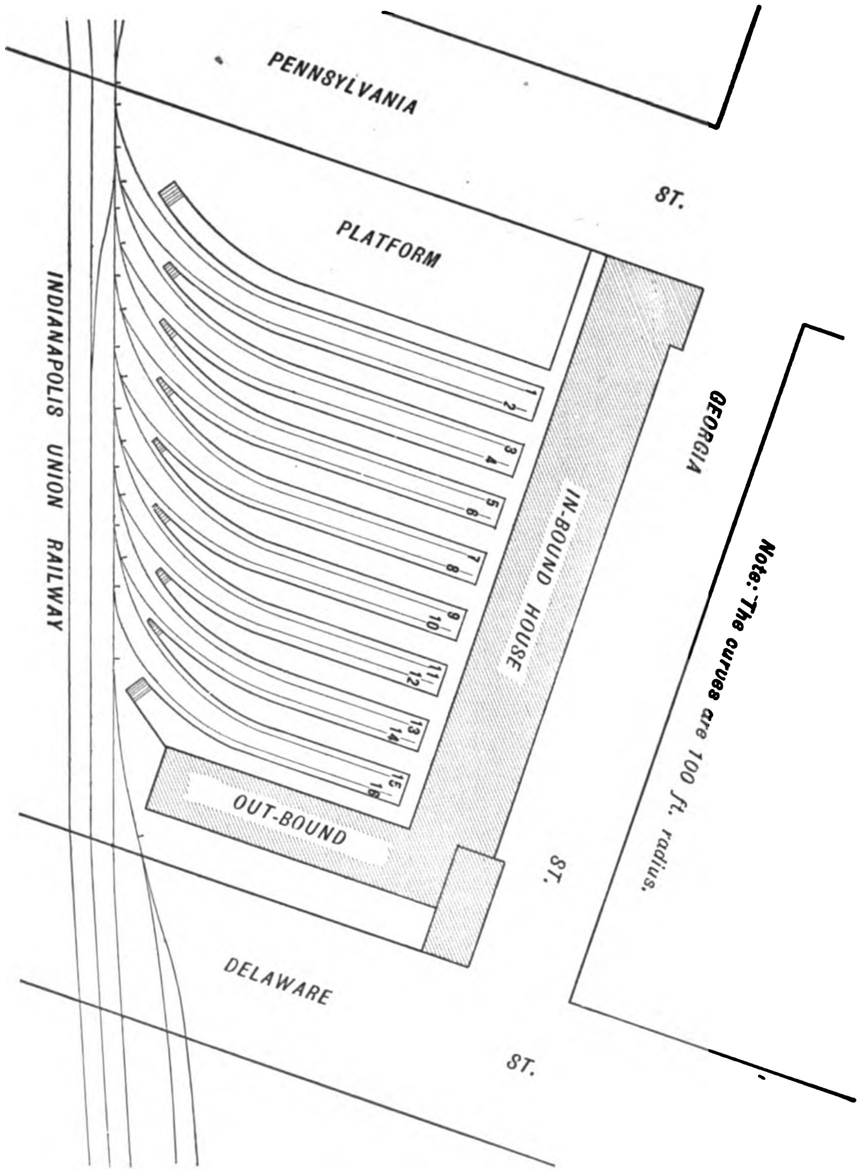


FIG. 5. PLAN OF FREIGHT STATION AT INDIANAPOLIS, IND.; P., C., C. & ST. L. RY.

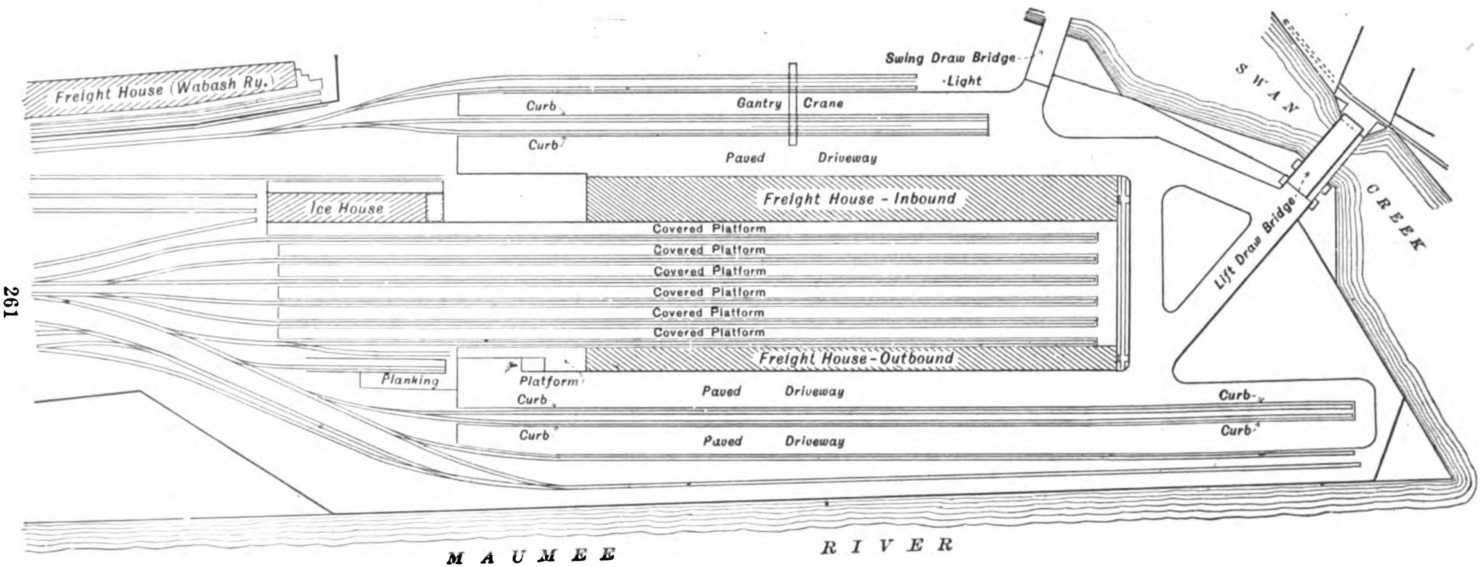
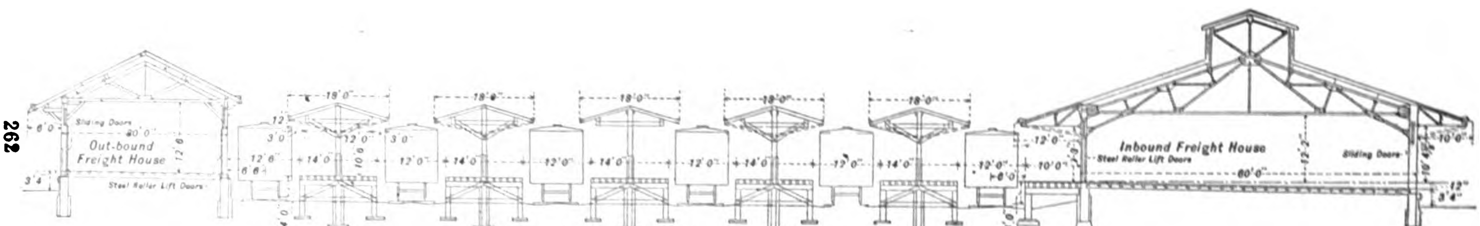


FIG. 6. PLAN OF NEW FREIGHT TERMINAL AT TOLEDO, O.; L. S. & M. S. RY.



CROSS SECTION THROUGH FREIGHT HOUSES AND TRANSFER PLATFORMS.

FIG. 7. SECTION OF NEW FREIGHT TERMINAL AT TOLEDO, O.; L. S. & M. S. RY.

For handling freight in a warehouse, pier shed or freight house, the following systems may be used: (1) Conveyors (roller, chain, belt, platform, etc.); (2) overhead traveling cranes; (3) carrier systems. Freight handling in railway storage warehouses was described in our 1908 report, and particulars of the extensive crane equipment in a British railway freight warehouse are given in Appendix E.

Freight handling by machinery may be divided into two classes: First—In warehouses and steamship piers, where the movement is mainly longitudinal. Second—In freight houses, where there are numerous movements in different directions. The former case is much the simpler, but it may be found practicable to introduce mechanical handling, so as to reduce the amount of trucking in the latter case. The Committee calls special attention to the opinions quoted below, especially that expressed by Mr. Starr, of the Pennsylvania Lines:

"*First*—The Pennsylvania System has, so far as I know, no machinery whatever at freight warehouses for the purpose of handling freight from and to platforms, in or out of cars, nor for the purpose of transferring between cars. We have a few city warehouses of what is termed double-deck design, where the freight is transferred between the truck and car platforms by means of elevators.

"There is, in my judgment, a wide field for improvement in the railways' methods of handling freight to and from cars, and I believe that a great deal of money could be saved by properly equipping some of the larger freight warehouses with suitable devices for handling freight. This particular feature of our business has been neglected, and I think you would be doing a good work in calling the attention of the railways to that fact. Many manufacturing plants whose business is small compared with one of our large freight warehouses, are far ahead of us in the use of labor-saving machinery for transporting material.—A. B. Starr (General Superintendent of Freight Transportation, Pennsylvania Lines)."

"*Second*—In relation to the use of freight handling and conveying machinery in railway freight houses, transfer houses and warehouses, I beg to advise that, with the exception of fixed and traveling cranes, which are a necessity, I know of no machinery such as movable platform, overhead trolleys or conveyors, that would in any way increase the efficiency of a proper truck service, or taking the place of such service. We have no freight houses that are equipped with other than trucks and suitable cranes.—F. P. Abercrombie (Superintendent New Jersey Division, Pennsylvania Railroad)."

"*Third*—For general merchandise, I think a moving platform might be economical in a freight house where a large amount of business is done. At a point where the area available is insufficient to handle the business on one floor, the freight house should have several floors, with

elevators in addition to the moving platform. Special conveyors may be used for special business.—C. F. W. FELT (Chief Engineer, Gulf, Colorado & Santa Fe Railway)."

"*Fourth*—The conditions under which it is necessary to handle freight at freight houses and transfer stations differ so materially that it is difficult to outline any standard arrangement of machinery or carriers which could be used to advantage. At our Watertown transfer house we handle a large number of carriages, and we have an overhead trolley system, extending from the receiving platform to the cars, so that it is not necessary to truck this freight other than to place it in the car. At our piers at New York terminals we have barrel conveyors, which are used for running flour, etc., from the cars to the lofts for storage, and from the lofts to the loading platforms. We also have special machinery for the handling of raw sugar in bags.—F. E. WILLIAMSON (Superintendent of Terminals, New York Central Lines)."

"*Fifth*—For a transfer house with a large business, a telpherage system for handling large loads of freight could be used advantageously. I do not think this would be economical for a freight station, as the articles handled would vary too much in quantity and kind.

"We proposed to install at Pier No. 8, Locust Point, Baltimore (now under construction), a telpherage system, designed to carry large loads of freight and distribute it at the various points throughout the house, and also deliver it to cars or wagons. This system consists of steel runways, on which are operated electric hoists and travelers.

"This is the only point at which we contemplate at this time installing machinery for the purpose of aiding the distribution of freight. At Chicago, we have elevator connection with the subway, by which cars from the subway are raised to the elevation of our freight-house floor and run on tracks for unloading. This facilitates the receiving of freight from the subway, but, of course, does not affect the distribution. —G. L. POTTER (Third Vice-President, Baltimore & Ohio Railroad)."

"*Sixth*—About a year ago, I endeavored to make a study of this question with a view to adopting some method of mechanical handling of merchandise freight at some of our most important freight stations. The need of mechanical appliances in this connection is much greater in connection with a large inbound freight house than it is in a modern outbound house, where the arrangements are usually such that the trucking of freight is reduced to a minimum. I confined my attention, therefore, to the question of the inbound house.

"There seem to be two or three main points to be considered:

"(A) The utilization of every possible square foot of floor space for storage purposes.

"(B) The transportation of the freight from any point in the house to any other point in the house (including, if you please, delivery

on wagons standing at the doors) by mechanical means with the greatest amount of rapidity and the least possible interference with other operations that might be going on within the house simultaneously.

"(C) The problem of handling in this manner miscellaneous packages of all sizes, shapes and weights.

"I consulted a good many manufacturers, engineers and a number of freight house employés who were thoroughly familiar with the practical everyday workings of the business. I came to the conclusion that to meet all of the requirements, there was only one machine that could be favorably used, namely, an electric traveling crane, supplemented, perhaps, by two trolley hoists operating for the full length of the house, one on each side, and depending upon the design of the house itself, whether they operate immediately inside the walls or immediately outside the walls.

"The methods which seemed the most practical to me for the handling of small package freight, was by means of stoutly constructed platforms of convenient size, having chains attached to the four corners, which could be swung from the hook of the crane. Several of these could be placed conveniently near the door where a car was being unloaded and the freight deposited directly upon them by men who were breaking out the car. They could then be handled either by the trolley hoist or the traveling crane, or both, and set down at any spot in the freight house where it might be desired to place them for storage, or placed directly on the wagon waiting to receive them, platform and all. The size of the platform could be made to conform as nearly as practicable to the average size of the ordinary freight transfer truck or wagon.

"The problem which I was endeavoring to solve had some very important limitations and restrictions, on account of our being obliged to apply it to a building originally designed with no idea of anything of this nature. I believe it would not be at all difficult in the building of a new freight house to so design it to allow for the mechanical handling of freight along the lines indicated above, and doing it with rapidity and economy of operation which would reduce by at least 50 per cent., and probably more, the expense that is now incurred in the ordinary inbound house, where the freight is handled entirely by hand. Of course, this same idea could be enlarged and elaborated upon in connection with combined freight and storage houses, where it is desirable to utilize two or three floors of the building.

"So far as I can see, this plan seems to be the most feasible of any that have been suggested up to the present time for the handling of miscellaneous package freight in an inbound freight house.—GEO. G. YEOMANS (Assistant to the President, Wabash Railroad)."

Cranes are used in some warehouses, but as a rule the height of the ordinary freight house is not sufficient to permit the use of an overhead traveling crane. A railway warehouse in Scotland has re-

volving cranes (with horizontal booms) suspended from runways. These give greater flexibility and capacity than an overhead traveling crane with hoisting trolley. (See Appendix D.)

Traveling hoist installations have been planned. One manufacturer states that he has figured on several such installations, but that with enough trackage to cover the floors satisfactorily the cost is so high that the proposition is usually dropped. In some of these systems there is a "herringbone" arrangement; the main runway extends through the central bay of the building. On this travels a bridge for the hoist. At intervals there are branch runways at right angles to the main runway. The bridge can be stopped in line with any one of these and the trolley hoist run out on the spur.

At the appraisers' warehouse in New York there are four I-beam runways with four double-motor electric traveling hoists. These hoists are used for carrying freight from the warehouse to wagons on the outside.

In the telpherage system, the trolley hoist handles wheeled platforms or trucks. This was described in our 1908 report, and (as stated elsewhere) it is to be used at Baltimore by the Baltimore & Ohio Railroad.

Gravity conveyors include inclines and spiral chutes. The former are used in several industrial plants. The floor is composed of rollers. One form of spiral chute was described in our report of 1908. This has a spiral platform in the annular space between two steel cylinders extending from top to bottom of the warehouse. Other systems have an open spiral trough, or a spiral frame carrying a floor of rollers.

At the Minnesota Transfer, near St. Paul, about 1,700 ft. of a portable gravity conveyor system is used for unloading shingles and lumber from railway cars, and distributing them through the yard and warehouse. There are two parallel rows of small wheels or rollers forming the conveyor, and their frames are supported at intervals by light steel cross frames or bents. The grades may be from 3 to 4 per cent. The Virginia Street Dock & Warehouse Company, of Seattle, uses the same system for carrying packages from steamers into the warehouse and from the warehouse to cars and local steamers. A similar system, but with rollers forming the floor, is used at some of the shipping stations of the Anheuser-Busch Brewing Association. This is shown in Fig. 8.

Various systems of belt, roller, chain and platform conveyors are in extensive use in industrial establishments and warehouses. In many cases they are operated in connection with elevators and inclines for raising and lowering the packages.

The general opinion seems to be that there is no machinery or conveyor equipment that can successfully handle freight in ordinary freight houses, and that it would be difficult to devise a satisfactory equipment for such service. The special difficulties are: First—the

great variety in shape, size and weight of the packages; Second—the fact that packages delivered by teams at the various doors have to be distributed to cars at various points on the other side of the house. Ordinary conveyors are not adapted to this service, being more suitable for carrying packages between fixed points of receipt and delivery.

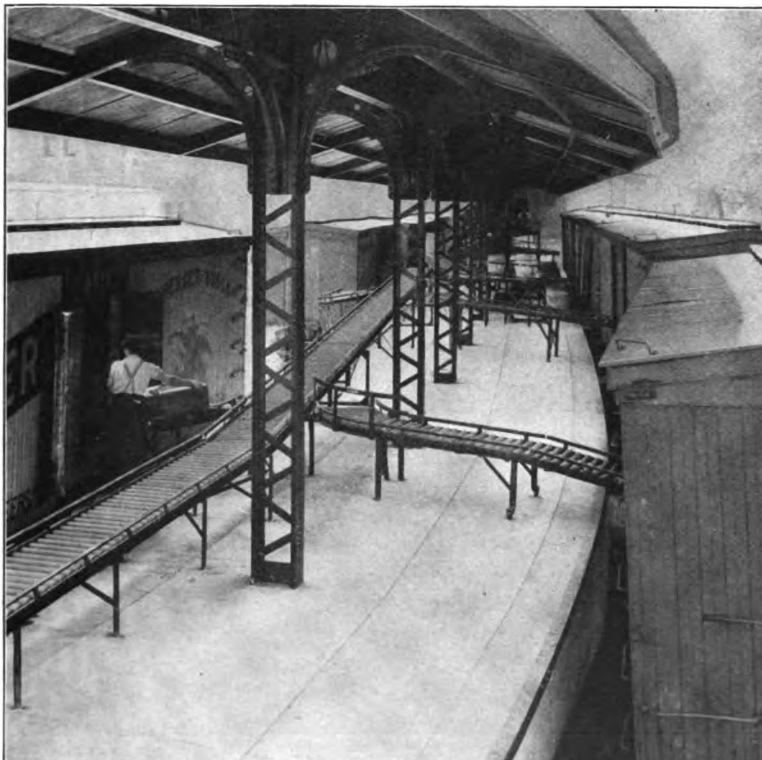


Fig. 8. Inclined Roller Conveyor for Delivering Packages to Cars at Anheuser-Busch Co.'s Loading Station; St. Louis, Mo. (Alvey-Ferguson Co., Builders.)

Two possible methods of handling freight between variable points are movable platforms for the packages, or means of moving the trucks by mechanical power so as to reduce the time and labor involved in moving them by hand over long distances. A traveling platform level with the floor has been devised, moving at slow speed, so that men, trucks and teams can cross it. As proposed for an inbound freight house of the Baltimore & Ohio Railroad, the moving platform would form a belt line; one side would be near the track side and the other

delivered at the end or from a steamer has to be transferred for a considerable part of the length of the pier.
near the team delivery side. Packages (or trucks) from the cars would be dropped on the moving platform. The house would be divided into sections, with a man to each, and each man would pull off the platform the freight for his section as it passed him. In another system, the platform would be a single line only, the return side being underground. This was designed more particularly for steamer piers, where freight

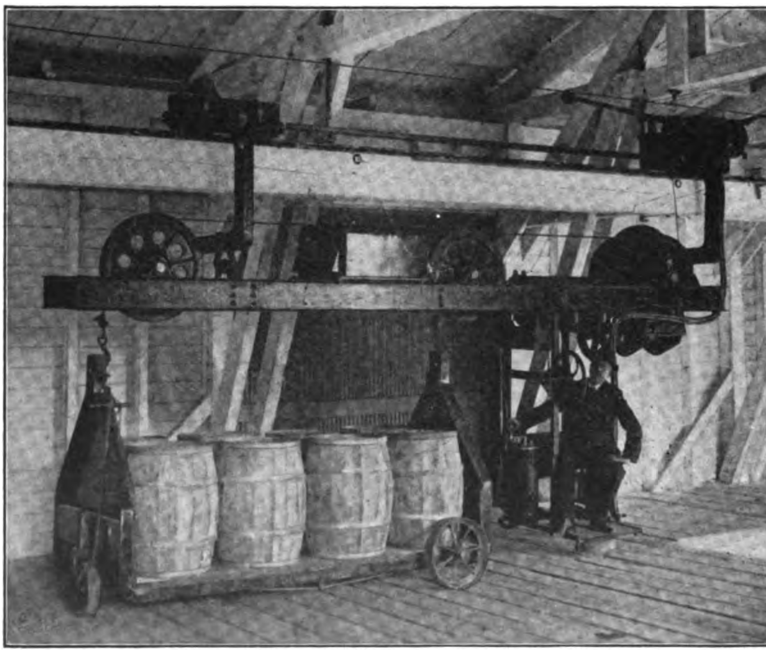


FIG. 9. TELPHERAGE FREIGHT HANDLING SYSTEM AT THE DOCK OF THE OLD DOMINION STEAMSHIP CO.; RICHMOND, VA. (DODGE COAL STORAGE CO., BUILDERS.)

For handling the trucks, the Committee is able to present information as to two systems: (1) An overhead runway system; (2) An underground cable system.

(1) The telpherage or overhead system may be described here, as it is in use at a steamship pier, and is to be introduced for the same purpose by the Baltimore & Ohio Railroad. (This is the Dodge system.) In this system a pair of trolleys riding on an elevated runway carry a frame with hoists for raising and lowering trucks or wheeled platforms. Current for electric traction is taken from an overhead wire,

and an attendant riding with the machine controls the traveling and hoisting movements. This system has been in operation for about four years on the pier of the Old Dominion Steamship Company, at Richmond, Va. It handles 3-ton loads between the wharf and the railway warehouse and cars. This is shown in Fig. 9. It is said to show a great saving in cost over the old hand-truck method, besides being able to handle freight more rapidly and with much greater ease.

A telpherage installation designed for the Bergen (N. J.) freight house of the Erie Railroad is shown in Fig. 10. There are three platforms, each 1,400 ft. long, and three telpher tracks (one over the center of each platform) connected by loops at the ends. Ten telpher machines operating at one time on the three tracks, all machines following each other in the same direction around the loop, as shown by arrows, would provide for a movement of 1,000 tons of freight per day of 20 hours. Each machine was required to make one round trip of 3,000 ft. in six minutes (at the rate of 10 trips per hour). The average speed would therefore be 500 ft. per minute, including all stops and slow-downs, and the maximum speed of traveling will be 1,500 ft. per minute. The telpher carrier is shown in Fig. 11.

The cycle of operations is as follows: Each telpher passing along telpher track "A" stops over a loaded truck, which has been placed directly beneath the telpher runway. The operator lowers the bail, engaging the hooks with the ends of the carrier, and hoists the load (maximum distance 15 ft.). The telpher then runs in the direction of the arrow, and takes either track "B" or "C," as required, and stops at some designated point, lowers the truck, which automatically disengages itself from the bail on touching the floor. The telpher then continues and picks up an empty truck (in waiting directly beneath the telpher runway) and returns to track "A." It lowers the empty carrier and proceeds to the next loaded one, thereby completing its cycle.

The cost of handling freight in the above manner has been figured at 5 cents per ton. This is based on carrying an average load of only 1,000 lbs. at each trip, although the machines were to have a maximum capacity of 2,000 lbs., which seemed to be sufficient to handle the bulk of the freight. This cost per ton is also based on electric power supplied at 4 cents per kilowatt hour, and a telpher rider at 20 cents per hour. This does not include the labor for loading the freight onto the trucks and placing them beneath the telpher runway, nor for unloading the trucks and replacing them under the runway. The figures given above are those of the manufacturers of this system.

This same system has been proposed for connecting freight houses and steamship piers, and plans were made for an installation for the Illinois Central Railroad at Nonconnah, Tenn. This was to transfer logs and cotton bales between river barges and railway cars, and the telpher carriers were to handle 10-ton loads. None of these plants have been installed.

The Memphis Warehouse Company has overhead trolley tracks

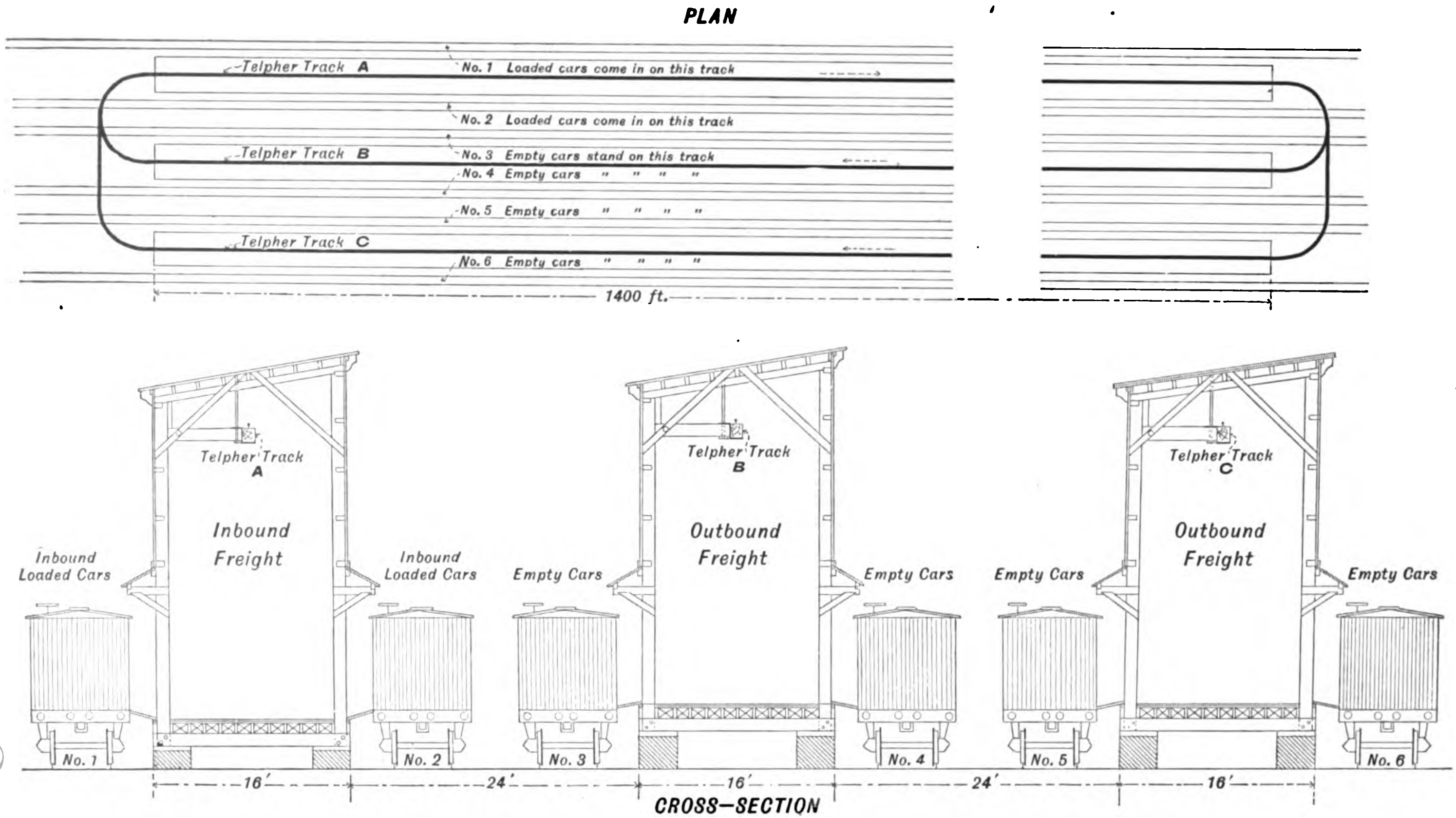


FIG. 10. TELPHERAGE FREIGHT HANDLING SYSTEM DESIGNED FOR THE FREIGHT HOUSE OF THE ERIE R. R., AT BERGEN, N. J.

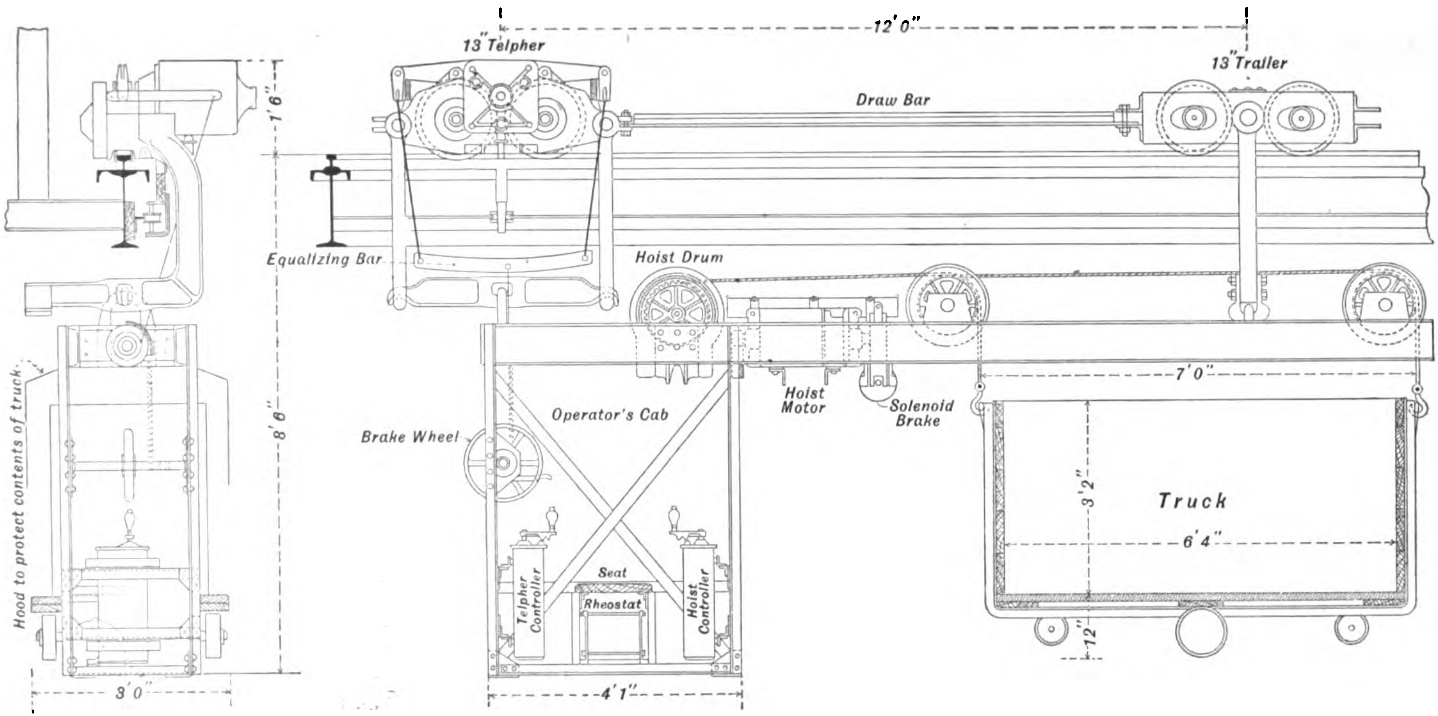


FIG. 11. CARRIER FOR TELPHERAGE FREIGHT HANDLING SYSTEM.

(Breck system) for handling cotton. The trolleys are not motor-driven, however, but the tracks have a slight grade so that the load moves by gravity. The grade begins at the beginning of the inbound platform and extends through the plant to the end of the outbound platform, a distance of about 1¼ miles. The arrangement permits of placing four (or even six) trains of 25 cars each at the inbound platforms at one time, without "spotting." This makes it possible for one switching engine and crew to do the work, while ordinarily three or four engines would be required. There are about three miles of the trolley runway and six miles of railway tracks. The cost of handling by the telpherage system is said to be only about one-eighth of the cost of teaming. The company has an extensive cotton warehouse and compress plant, with storage capacity under cover for about 125,000 bales.

(2) A system of handling freight trucks by a traveling chain has been patented by a firm of conveyor manufacturers, and is intended to reduce the labor of the trucking in a longitudinal direction. The idea was to devise a system that would provide for taking freight from any car along the platform and delivering it to any other car as conditions require. In order to accomplish this, it was found desirable to use the ordinary hand-truck, with slight modifications, so that it can readily be wheeled around from one place to another by manual labor when desired. The truck travels upon a narrow-gage track, and is provided with special attachments to engage an endless chain set underneath the track. This driving chain lies entirely beneath the floor, and is out of the way. As there is only a groove 1 in. wide in the floor, there is no danger of accidents, and the floor is left entirely clear to truck across or walk upon at any time.

An interlocking roller chain is provided for the purpose of giving motion to the trucks. This chain is provided at regular intervals with a lug, which is arranged to engage with a swinging lug which is attached to the axle of the truck. This engagement takes place the moment that a truck is set level upon the track, and immediately propels the truck forward at a uniform speed. The trucks are released from engagement immediately after they are raised from the track, or switched off the main track, so that there is no time lost in engaging or disengaging the trucks. The track consists of a flat steel rail, set flush with the floor. It is practicable to place switches at each car, so that a truck may be switched directly from the conveyor into the car door. These switches may be set at whatever intervals conditions require, and may all be controlled from a central point, so that trucks may be automatically carried from one car to any other. When a loaded truck is delivered at the car door it can then be picked up and wheeled by hand through one car into another or back to the end of the car for storing this load. When the truck is empty, it is only necessary to push it out of the car door to edge of platform, where it is taken up by the conveyor and delivered to its desired destination for another load.

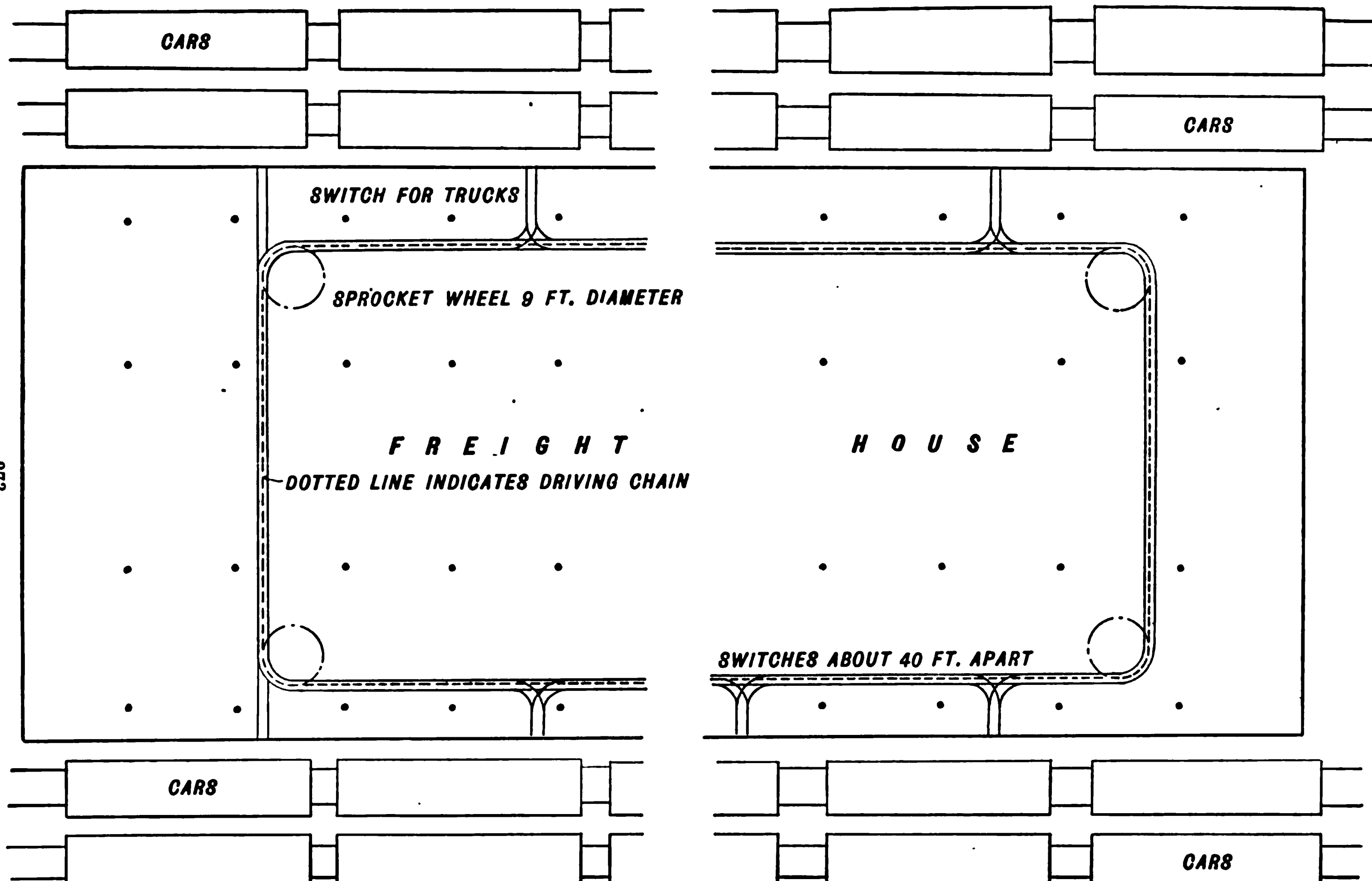


FIG. 12. PLAN OF PROPOSED FREIGHT HANDLING SYSTEM FOR FREIGHT HOUSES; WITH CONTINUOUS CHAIN ENGAGING WITH HAND TRUCKS (ALVEY-FERGUSON CO., BUILDERS.)

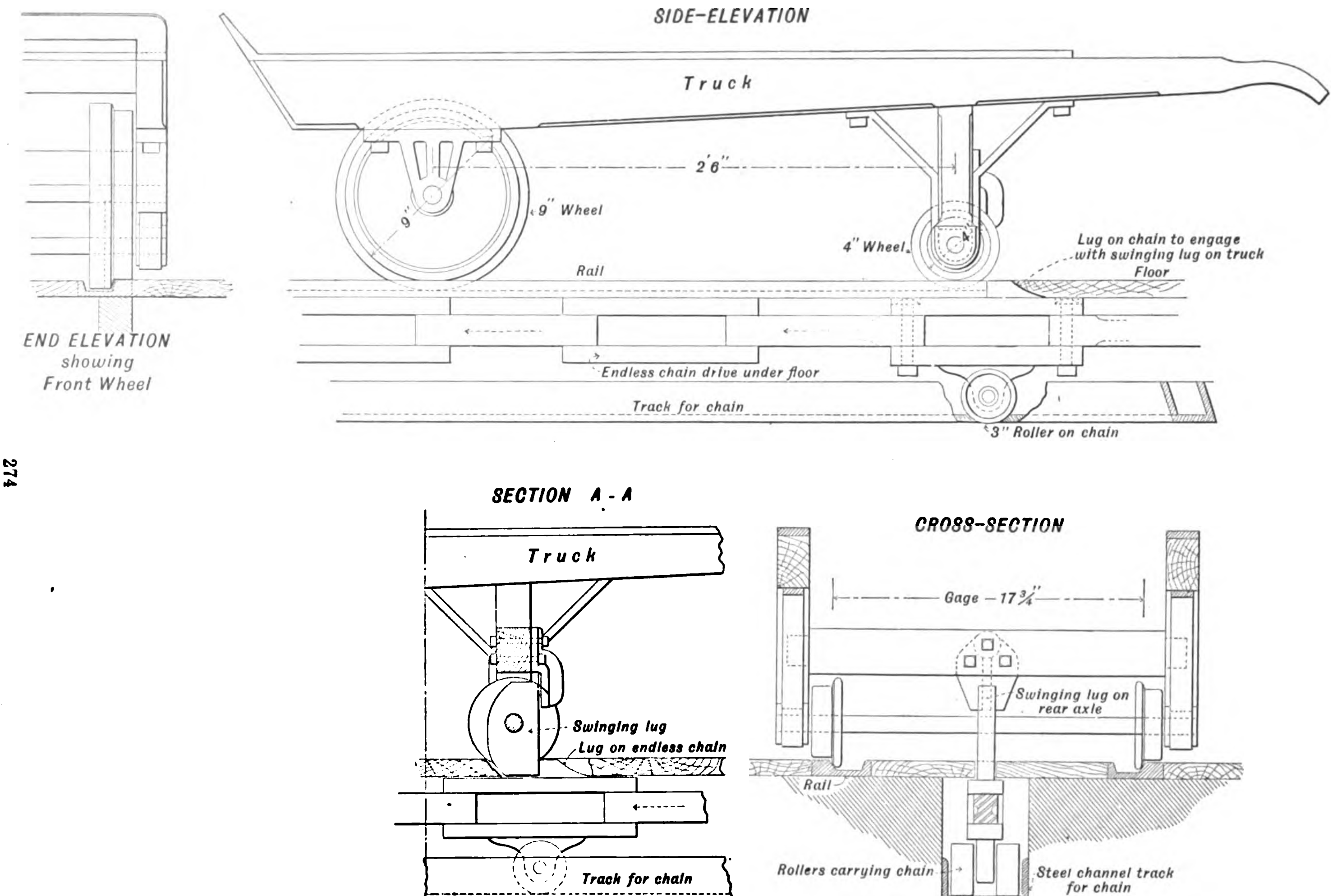


FIG. 13. HAND TRUCK FOR USE WITH CHAIN CONVEYOR SYSTEM.

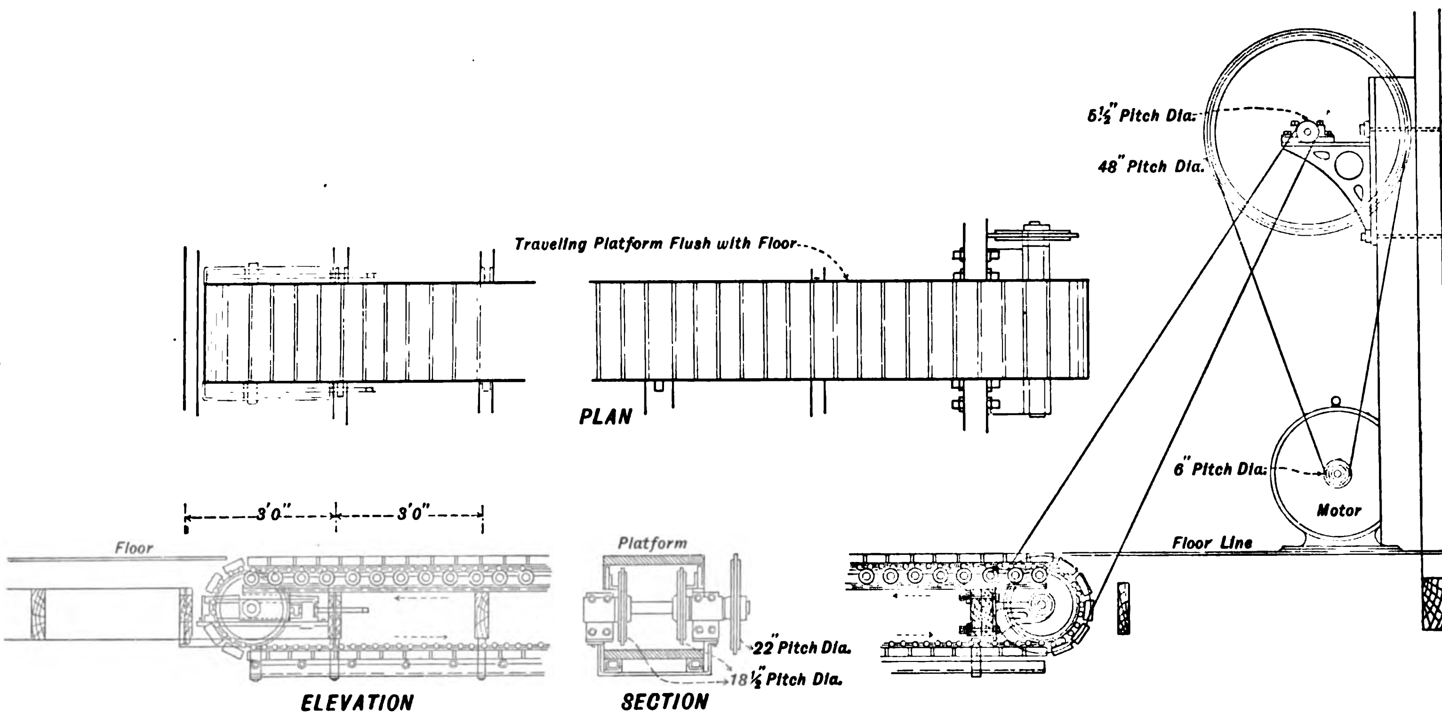


FIG. 14. TRAVELING PLATFORM FOR FREIGHT HOUSE (SPENCE MANUFACTURING CO., BUILDERS.)

Fig. 12 is a general plan of the arrangement and Fig. 13 shows the details. This conveyor arrangement can be adapted to operate through two or more floors where necessary, as the design includes provision for a means of automatically elevating the trucks from one floor to another. The trucks can be moved in various directions, as conditions may require.

The quantity of freight moved will depend upon the speed of the conveyor and the number of trucks used. It is proposed to run it at 60 ft. per minute, providing one truck for each 12 ft. of conveyor. The trucks are estimated to carry 1,000 lbs. each. On an average, this would be 5,000 lbs. of freight per minute, or 300,000 lbs. per hour, making a total for ten hours' work of 1,500 tons. This would probably answer the requirements of most railway transfer houses, or at least of the number of cars which could be located alongside of one transfer platform. If greater capacity should be required, the size of trucks could be increased, as could also the speed of conveyor.

Another method proposed is shown in Fig. 14. Here the slow-moving platform is flush with the floor. It is intended more particularly for piers and transfer stations.

Your Committee has no conclusions to present as to this matter, but would recommend that consideration be given to the practicability of applying freight-handling machinery in individual cases.

Respectfully submitted,

F. S. STEVENS, Superintendent, Philadelphia & Reading Railway, Reading, Pa., *Chairman.*

E. E. R. TRATMAN, Resident Editor, *Engineering News,* Chicago, Ill., *Vice-Chairman.*

HADLEY BALDWIN, Superintendent, Cleveland, Cincinnati, Chicago & St. Louis Railway, Mattoon, Ill.

G. H. BURGESS, Principal Assistant Engineer, Erie Railroad, New York.

L. G. CURTIS, Division Engineer, Baltimore & Ohio Railroad, Chicago.

A. H. DAKIN, JR., Engineer, Milwaukee Terminal Ry., Seattle, Wash.

H. T. DOUGLAS, JR., Chief Engineer, Wheeling, Lake Erie, Wabash-Pittsburg Terminal and West Side Belt Railways, Cleveland, Ohio.

A. C. EVERHAM, Assistant Tunnel Engineer, Detroit River Tunnel Company, Detroit, Mich.

A. P. GREENSFELDER, Laclede Building, St. Louis, Mo.

F. G. JONAH, Terminal Engineer, New Orleans Terminal Company, New Orleans, La.

B. H. MANN, Signal Engineer, Missouri Pacific Railway System, St. Louis, Mo.

J. D. MASON, Civil Engineer, Chicago, Ill.

A. MONTZHEIMER, Chief Engineer, Elgin, Joliet & Eastern and Chicago, Lake Shore & Eastern Railways, Joliet, Ill.

G. F. Morse, Assistant Engineer, Central Railroad of New Jersey, New York, N. Y.

Samuel Rockwell, Chief Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

C. S. Sims, Vice-President and General Manager, Delaware & Hudson Railroad, Albany, N. Y.

C. H. Spencer, Engineer, Washington Terminal Company, Washington, D. C.

C. H. Stein, Engineer Maintenance of Way, Central Railroad of New Jersey, Jersey City, N. J.

Committee.

Appendix A.

DETAILS OF OPERATION OF HUMP YARDS.

I. BALTIMORE & OHIO RAILROAD.

(Brunswick, Md.; Eastbound Hump Yard.)

1. Maximum number of trains entering receiving yard in one hour, 6.
2. Average number of cars per train, 45.
3. Average number of trains entering receiving yard in 24 hours, 30.
4. Number of cars and tonnage in average train pushed over hump:
   (a) With one engine weighing 72.5 tons, 45 cars, 3,000 tons.
   (b) With two engines weighing 72.5 tons, 40 cars, 3,350 tons.
5. Average number of cuts per train, 23.
6. Percentage of cars weighed that pass over the hump, 2 per cent
7. Cars are uncoupled to be weighed.
8. The scale is not on the hump. It is in the westbound yard. Cars are switched over hump, then transferred to westbound yard and weighed. The latter is not a gravity yard.

10. The scale should be on the hump, between the apex of hump and classification yard switches, so that cars going over the hump can be weighed as the trains are switched, and cars dropped in proper track in the classification yards. The scale located in westbound yard requires freight to be switched and taken into that yard, weighed and returned to receiving yard and rehandled over the hump.

11. There are three engines: two used to push trains over the hump, double-headed with heavy trains; also used to push down and couple up cars on tracks in classification yard. The third is at the east end of classification yard to make up trains, etc.

12. The hump engine keeps its train moving until riders are all used.

13. The average classifying capacity of the hump as determined by continuous operation is as follows:

One hour, 50 cars.
Five hours, 250 cars.
Ten hours, 500 cars.

14. One hour is allowed for meals; one engine going to the fire track at noon, and one at 5 p. m., for coal and sand and to have fire cleaned.

15. The hump is in actual operation for seven hours out of ten, ten hours being a working day.

16. There are 11 car riders employed. They walk back to the hump most of the time. When the engine is being used to push cars on the classification tracks, they ride back on the engine.

17. The number of car riders employed is only enough to handle the average movement with nearly continuous operation.

18. The proper number of car riders to employ is determined from advance reports. The riders are regulated by these reports.

19. Electric switches are used; they require one man by day and one man at night.

20. No advantage can be gained by the use of two scales on a hump.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is a little over 10 cents.

2. BALTIMORE & OHIO RAILROAD.

(New Castle Yard; New Castle Junction, Pa. See Fig. 15.)

1. Maximum number of trains entering receiving yard in one hour, 4.

2. Average number of cars per train, 50.

3. Average number of trains entering receiving yard in 24 hours, 12.

4. The average train pushed over hump with one 50-ton engine weighs 2,500 tons.

5. Average number of cuts per train, 28.

6. Percentage of cars weighed that pass over the hump, 30 per cent.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump, 50 ft. from the summit.

9. The classifying capacity of the yard is not diminished by placing the scale on the hump.

11. Three engines are employed regularly; two classifying freight eastbound and westbound; one making up trains for the west, assisting to handle fast freight and miscellanenous yard work.

12. The hump engine does not keep its train moving continuously, but stops are made between cuts.

13. The classifying capacity of the hump as determined by continuous operation is as follows:

	Average.	Maximum.
One hour	25	75
Five hours	125	375
Ten hours	250	750
One day	600	1,700

14. One hour is allowed for dinner, one hour for supper; the engines have fires cleaned during meal hours.

15. The hump is in actual operation for 20 hours in a calendar day under normal operating conditions.

16. There are five car riders employed. They walk back to the hump.

17. The five car riders are able to handle the average movement with continuous operation of hump.

18. As to determining the proper number of car riders, the five riders are sufficient under normal conditions. When work becomes very heavy, one or two additional are put on. This is only necessary when there is considerable increase in westbound movement.

19. The switches are operated by hand; 14 to one man.

20. No advantage can be gained by the use of two scales on a hump.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 8½ cts.

3. BALTIMORE & OHIO RAILROAD.

(Holloway Yard; Holloway, O.)

1. Maximum number of trains entering receiving yard in one hour, 4.

2. Average number of cars per train, 34.

3. Average number of trains entering receiving yard in 24 hours, 15.

4. The average train pushed over hump has 34 cars and weighs 1,913 tons. Only one engine is used, weighing 96 tons.

5. Average number of cuts per train, 15.

6. Percentage of cars weighed that pass over hump, 70 per cent.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump; 127 ft. 10 in. from the summit.

9. The scale located on the hump does not diminish the classifying capacity of the yard. If located elsewhere it would make extra switching.

10. The hump is the proper place for the scale.

11. There are two locomotives employed in the yard, one being on the hump. The number is increased or decreased as business warrants.

12. The hump engine makes stops between cuts to allow switch tenders time to do their work.

13. The classifying capacity of the hump, as determined by continuous operation, is as follows:

	Average.	Maximum.
One hour	20	70
Five hours	100	350
Ten hours	200	700
One day	400	1,400

Note: This number could be put over, but the yard would hold them back.

14. One hour is allowed for dinner and another for supper.

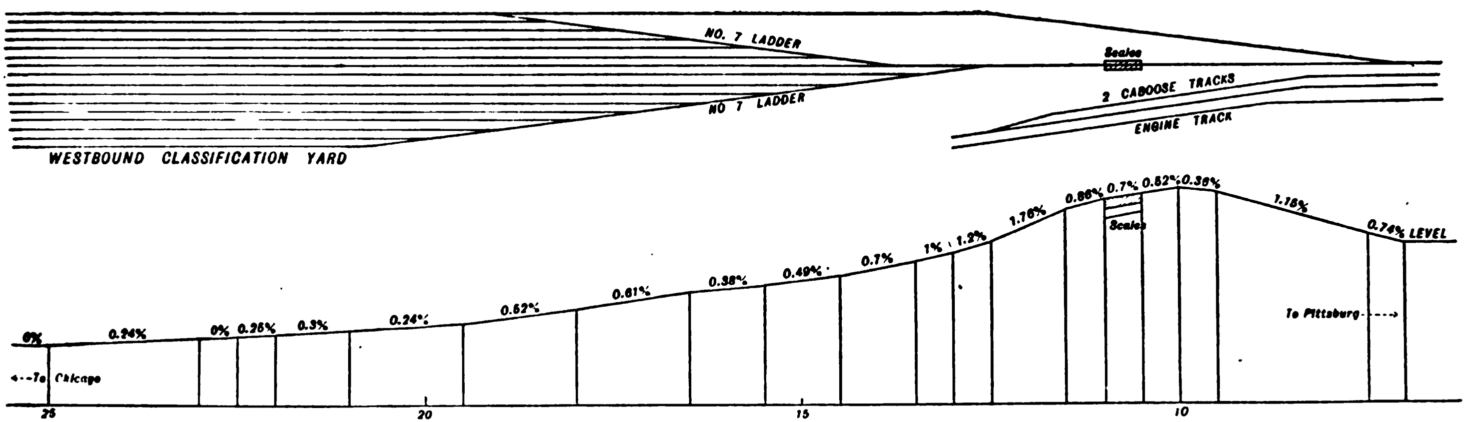


Fig. 15. Plan and Profile of Hump Freight Yard at Newcastle, Pa.; B. & O. R. R.

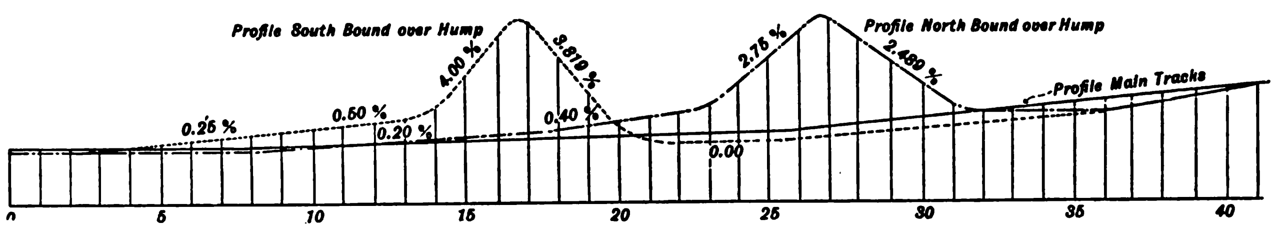


Fig. 17. Profile of Hump in Freight Yard at Oneonta, N. Y.; D. & H. Co.

15. The engine works 20 hours, but the hump is actually in service normally 10 hours.

16. The number of car riders employed is 7. They walk back to the hump. The number is regulated as business justifies.

17. The number of car riders employed is sufficient to handle the average number of cars.

18. The proper number of car riders is determined according to trains reported coming and anticipated movement outward.

19. The switches are operated by hand; nine to one man.

20. No advantage can be gained by the use of two scales on a hump.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 11 cts.

4. CANADIAN PACIFIC RAILWAY.

(Winnipeg Yard.)

1. Maximum number of trains entering receiving yard in one hour, 5.

2. Average number of cars per train, 50.

3. Average number of trains entering receiving yard in 24 hours, 40.

4. One 65-ton engine will handle 2,500 tons over the hump; two engines, 5,000 tons.

5. Average number of cuts per train, 25.

6. None of the cars are weighed that pass over hump.

8. The scale track enters hump track at each end of hump.

9. Whether the scale or the hump will diminish the classifying capacity of the yard depends largely on the traffic which is through yard as to whether the scale should be located on the hump or alongside the hump. If the larger number of the cars require to be weighed, it should be located either on the hump or at some place in the approaches to the hump where the velocity of the cars would not be too great to have them weighed while moving. When a small percentage of the cars are to be weighed, it would be cheaper to run them over the hump and have a reverse movement if necessary to have them weighed, running all cars into a track used for that purpose.

11. There are 19 locomotives employed in the yard.

12. The hump engine keeps its train moving continuously.

13. The classifying capacity of the hump, as determined by continuous operation, is as follows:

One hour, 100.
Five hours, 500.

14. One hour in each shift is allowed for meals, and for changing engines and crews, cleaning fires, etc.

16. From 5 to 10 car riders are employed. They walk back to the hump.

17. Five car riders are sufficient in summer; 10 will keep continuous switching going during the fall rush.

19. The switches are operated by hand; 12 switches to one man.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 5 cents.

5. CHICAGO & EASTERN ILLINOIS RAILROAD.

(Haney, Ill.; Northbound Yard.)

1. Maximum number of trains entering receiving yard in one hour, 4.

2. Average number of cars per train, 51.

3. Average number of trains entering receiving yard in 24 hours, 18.

4. One engine weighing 113 tons can push 51 cars in summer and 35 in winter. Two engines (113 tons and 80 tons) in winter can push 51 cars over the hump.

5. Average number of cuts per train, 35.

6. Percentage of cars weighed that pass over hump, 20 per cent.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump, about 110 ft. from the summit.

9. The scale located on the hump does not diminish the classifying capacity of the yard.

10. The scale should be located on the hump.

11. There are 3 hump engines and 3 transfer engines in winter; 2 hump engines and 2 transfer engines in the summer.

12. The hump engine keeps its train moving continuously at slow speed over the hump.

13. The classifying capacity of the hump, as determined by continuous operation, is as follows:

One hour, 85 cars.
Five hours, 425 cars.
Ten hours, 850 cars.

14. One hour is allowed for meals, and for changing engines and crews, cleaning fires, etc.

15. The hump is actually in operation 8 to 11 hours per day under normal operating conditions.

16. The number of car riders is from 12 to 16. They walk back except when rushed, when a carrying engine is put on.

19. The switches are operated by hand, 8 to one man.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 10 cents.

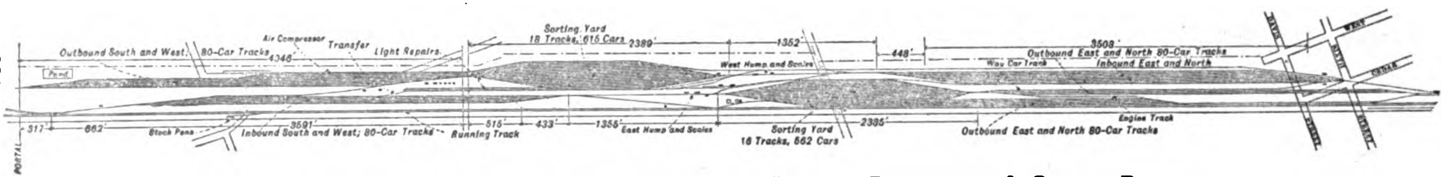


FIG. 16. PLAN OF FREIGHT YARD AT GALESBURG, ILL.; CHICAGO, BURLINGTON & QUINCY RAILWAY.

6. CHICAGO, BURLINGTON & QUINCY RAILROAD.

(Yard at Galesburg, Ill. See Fig. 16 and Appendix B.)

1. Maximum number of trains entering receiving yard in one hour, 8.

2. Average number of cars per train, 51 cars.

3. Average number of trains entering receiving yard in 24 hours, 50.

4. The average train pushed over the hump with one engine (weighing 101 tons) has 51 cars (1,559 tons).

5. Average number of cuts per train, 31.

6. Percentage of cars weighed that pass over hump, 25 per cent.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump, 50 ft. from the summit.

9. The scale located on the hump does not diminish the classifying capacity of the yard.

10. The scale should be located on the hump.

11. The number of locomotives employed in the yard is six; 2 hump engines that shove trains over the hump, 2 carrying engines used in carrying riders back and shoving tracks, 2 sorting yard engines making up trains.

12. The hump engine keeps its train moving continuously at slow speed over the hump.

13. The classifying capacity of the hump, as determined by continuous operation, is as follows:

One hour, 100 cars.
Five hours, 500 cars.
Ten hours, 1,000 cars.
One day, 3,026 cars.

14. One hour is allowed for meals, and for changing engines and crews, cleaning fires, etc.

15. The hump is actually in operation eight hours per day under normal operating conditions; 8 hours at night if business demands.

16. There are 10 car riders employed. They either walk or ride on the carrying engine.

17. The number of car riders employed is sufficient to handle average movements. It is increased as business demands.

18. The number is kept down to ten men, and as business demands the number is increased.

19. The switches are operated by hand. Each man has 7 switches.

20. No advantage can be gained by the use of two scales on a hump.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 11.9 cents.

7. CHICAGO, INDIANA & SOUTHERN RAILROAD.

(Yard at Gibson, Ind.)

1. Maximum number of trains entering receiving yards (2 receiving yards) per hour, 6.

2. Average cars per train, 40.

3. Average trains entering receiving yards (2) in 24 hours, 7.

4. The hump engines weigh 270,000 lbs., all on drivers; tender, 149,600 lbs.; total, 419,600 lbs. The grades are so light that two engines are not necessary. About 0.3 per cent. grade leading up to the hump. A train of 60 cars of coal can be pushed over the hump with one engine; cars weighing about 64 tons gross each.

5. The grades in the yard are so light that it is not necessary to cut the train.

6. There is no weighing of cars, as cars are weighed in outlying yards.

7. The cars are uncoupled to be weighed, but (as noted) cars are not weighed in the hump yard.

8. When business requires it, track scales will be installed on the hump.

9. The location of the scale on the hump would not diminish the classifying capacity.

10. Track scales should be on the hump.

11. There is one engine on the hump and one engine in the make-up yard.

12. Generally cars are kept moving, but occasionally the train is stopped if a car does not run well, or if a brake is not in good condition. The brake on each car is examined and tested before the car is cut off. One good brake is needed for three cars.

13. The classifying capacity of the hump yards is as follows, but the yard is not being used to its full capacity:

One hour, 100 and 100 cars.
Five hours, 400 and 500 cars.
Ten hours, 800 and 1,000 cars.
One day (22 hours), 1,700 and 2,000 cars.

14. One hour is allowed for meals and changing engines.

15. The hump is actually in operation for 11 hours per day.

16. The average number of car riders is 20. This varies according to amount of business handled. The men walk back to the hump.

17. Enough car riders are employed to permit of continuous operation.

18. The conductor in charge of the hump crew puts on enough men to handle the cars in one working day.

19. The switches are operated by hand. One switch tender handles three switches at the junction; two switch tenders handle seven switches each further down in the yard.

20. There can be no advantage in the use of two scales on the hump.

8. DELAWARE & HUDSON COMPANY.

(Yard at Oneonta, N. Y. See Fig. 17.)

1. Maximum number of trains entering receiving yard in one hour, 9.
2. Average number of cars per train, 43.
3. Average number of trains entering receiving yard in 24 hours, 30.
4. One 88-ton engine pushes an average train of 43 cars (2,300 tons) over the hump.
5. Average number of cuts per train, 28.
6. Percentage of cars weighed that pass over hump, 1 per cent.
7. Cars are uncoupled to be weighed.
8. The scale is located two miles from hump, at freight house. Cars are switched out and hauled to scales by yard engine.
10. The scale should be located on the hump.
11. There are six locomotives employed; 2 hump engines, 1 in each yard to make up trains, 1 to look after cripples, 1 for city business and freight house.
12. The hump engine keeps its train moving continuously.
13. The classifying capacity of the hump as determined by continuous operation, is as follows:

	Average.	Maximum.
One hour	32 cars	50
Five hours	160 cars	250
Ten hours	320 cars	520
One day	640 cars	1,000

14. One hour at midday is allowed for meals, and for changing engines and crews, cleaning fires, etc.
15. The hump is actually in operation 20 hours per day under normal operating conditions.
16. There are 7 car riders employed. They walk back to the hump.
17. The number of car riders employed is only sufficient to handle the average number.
18. The proper number of car riders is determined by the amount of business.
19. The switches are operated by hand, 4 switches to one man.
20. No advantage can be gained by the use of two scales on a hump.
21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is approximately 10.9 cents per car handled.

9. ERIE RAILROAD.

(Pen Horn Westbound Yard; two miles west from Jersey City.)

1. Maximum number of trains entering receiving yard in one hour, 8.
2. Average number of cars per train, 25.

3. Average number of trains entering receiving yard in 24 hours, 40.

4. With one engine weighing 155 tons, the average train pushed over hump is 25 cars.

5. Average number of cuts per train, 20.

7. Cars are uncoupled to be weighed.

8. There is no scale on the hump. The scale is on a separate lead at the east end of the eastbound classification yard. All cars to be weighed are classified on one track, and the string of cars is pulled up by a station engine over the scales by the dead rail. They are then weighed, being dropped back onto the lead of the eastbound yard. After all cars are weighed they are classified into the regular classification tracks at each end of the yard, having classification for all cars that are weighed at that point. (For hump grades see page 70.)

9. The classifying capacity of the yard would not be diminished if the scale was located on the hump.

10. If the scale is not located on the hump, it should be placed at the outgoing lead of the classification yard on a separate track, so that after the cars are weighed they can be properly classified at the head end of classification tracks, getting their turn of arrival.

11. There is one hump engine working 20 hours; its duties are to shove the cars from the receiving yard to the classification yard, properly classifying them. There is also one air-brake engine working 20 hours per day; its duties are to make up and test all trains ready for the road crews.

12. The hump engine keeps its train moving slowly and steadily over the summit of the hump.

13. The average classifying capacity of the hump is as follows: One hour, 50 cars (maximum 75 cars); 5 hours, 250 cars; ten hours, 500 cars; one day, 1,000 cars.

14. One hour is allowed for meals. The engine fires are cleaned and supplies taken in the same limited time.

15. The hump is actually in operation for 20 hours per day under normal conditions.

16. There are 12 car riders, 6 for each 10-hour shift. They return to the hump by walking.

17. This number of car riders is sufficient only for the average movement.

18. The number of car riders is determined by weather conditions and advance notice of incoming trains.

19. The switches are operated by hand; each switchman is assigned to ten switches.

20. No advantage can be gained by the use of two scales on the hump.

21. The cost per car for yard handling (from the time the road engine is cut off on the receiving track until the road engine is coupled to the train on departure track) is 9 cents.

10. LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

(Elkhart and Collinwood Yards. See Fig. 18.)

The Elkhart yard was built in 1903, and the Collinwood yard in 1904, and each has been in operation since. In both of them, however, some modifications have been made in the grades of the hump as originally designed, as experience has indicated the desirability of so doing. Neither of these yards has a scale on the hump. Mr. Samuel Rockwell, Chief Engineer, informs the Committee that this point was thoroughly considered. It seemed that since the proportion of cars to be handled over the hump which had to be weighed would always be small. The loss of time and inconvenience to the cars which did not need to be weighed would be more than enough to make up for the time which would be saved in not having to rehandle the cars which needed to be weighed. It was decided in the conferences on the subject that 25 per cent. of the total traffic is somewhere near the point where it might become desirable to place scales on the humps. But for a less percentage than this, they should not be so placed.

The practice is to drop cars needing to be weighed onto a track specially designed for them. At a convenient time an engine is attached to this string of cars, takes them out to a conveniently located scale, weighs them over this scale in the same way that a string of cars is ordinarily weighed, then moves them back into the receiving yard, and puts them over the hump again for classification.

Mr. Rockwell gives some results of actual cars handled in the Elkhart and Collinwood yards. It will be noticed that neither of these yards has ever been taxed to the utmost capacity, the figures given being simply figures from actual experience. The number of cars that can be handled over these humps in a given period, provided a sufficient number of cars is available (as stated by those in charge), is from 100 to 125 cars per hour; something over 500 cars in five hours, or 1,000 cars in ten hours. Of course the number that could be handled would depend very largely upon the number of cuts that have to be made. The traffic is a miscellaneous commercial traffic, and the average number of cuts is something like 55 cuts to a 70-car train. The maximum figures given above could, of course, be very much exceeded if there were materially less cuts per train. It must be understood that these maxima as given are purely working maxima under average conditions, and not by any means records made when conditions were prepared in advance for them.

Each of these yards has only one throat track over the hump, and Mr. Rockwell states that it has not appeared that there is an advantage in having two. It is, of course, apparent that if a wreck should occur on the throat track, it might not foul a second track, so that some time might be saved while the wreck was being cleared up. But it is considered that the unlikelihood of such a condition overbalanced the

disadvantage of always operating under normal conditions over tracks that would not be arranged in the best manner. It is assumed that in regular work two throat tracks could not be used at the same time, as the lines of traffic would necessarily be crossed unless there were in effect two yards with one track to serve each one. This does not refer to a run-around or passing track to permit fast-freight trains that are solid (or nearly so, and requiring little reclassification) to be moved around the hump. Such a track is necessary and is provided in the design.

(Operation of Elkhart and Collinwood Yards.)

1. Maximum number of trains entering the receiving yard in one hour; 12 (6 in eastbound and 6 in westbound yards at each place).

2. Average number of cars per train, 75.

3. Average number of trains entering the receiving yard in 24 hours, 15 each way at Elkhart; 20 each way at Collinwood.

4. One 135-ton hump locomotive pushes an average of 75 cars (2,500 tons). Two engines are used only in emergency, when the 135-ton engine is not available. The train is the same in any case.

5. Average number of cuts per train, 35 at Elkhart; 40 at Collinwood.

6. Percentage of cars weighed that pass over the hump, 4 per cent at both places.

7. Cars are set out to be weighed.

8. The scale is not on the hump, but a separate movement for weighing is made. At Elkhart the old scale in use prior to the construction of the hump is in use, and about two movements per day are made for weighing. At Collinwood there is a scale in each classification yard.

10. It is not considered wise to locate the scale on the hump.

11. There are four locomotives at Elkhart—1 on each hump and 1 in each classification yard making up trains. The same at Collinwood.

12. The hump engines keep their trains moving at slow speed.

13. The average classifying capacity of the hump at each place is 2,000 cars per 20-hour day. With heavy business this can be increased to 2,600 cars by cutting out the meal hours.

14. At each place, four hours per day are allowed for meals, changing engines and crews, cleaning fires, etc. If business is very heavy, continuous movement is maintained.

15. The hump is in actual operation for 20 hours per day under normal conditions.

16. At Elkhart there are 7 to 9 riders to each hump; they walk back to the hump. At Collinwood there are 4 to 16 riders to each hump; they return by an electric trolley car.

17. At both places the number of car riders is sufficient to handle the average movement with continuous operation.

18. The number of car riders is determined by advance reports of trains to arrive.

19. The switches are operated by hand; about 6 to each man.

20. The cost per car for yard handling is from 8 to 9 cents at each place. This is for work from the time the road engine is cut off on the receiving track until the road engine is coupled onto the train in the departure track.

11. LEHIGH VALLEY RAILROAD.

(East Oak Island Yard.)

1. Maximum number of trains entering receiving yard in one hour, 0.63.

2. Average number of cars per train, 35.

3. Average number of trains entering receiving yard in 24 hours, 15.

4. Number of cars and tonnage in average train pushed over hump: With one engine (87 tons), 20 cars, 900 tons; with two engines (174 tons), 40 cars, 1,800 tons.

5. Average number of cuts per train, 20.

8. There is no scale in the hump yard.

11. One locomotive is employed in the yard.

12. The hump engine keeps its train moving continuously while car riders are on hand.

13. The average classifying capacity of the hump is as follows:

One hour, 100 cars.
Five hours, 500 cars.
Ten hours, 1,000 cars.
One day, 2,400 cars.

14. One hour is allowed for lunch; no time for changing engines.

15. The hump is actually in operation for 10 hours in a calendar day.

16. Four car riders are employed. They walk back to the hump.

17. The number of car riders is sufficient to handle average movement.

18. The proper number of car riders to employ is determined from the number of trains to be drilled.

19. There are 20 switches, operated by hand by two men.

21. The cost per car for yard handling (from time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 6½ cents.

12. MICHIGAN CENTRAL RAILROAD.

(River Rouge Yard; Detroit District.)

1. Maximum number of trains entering the receiving yard in one hour, 3.

2. Average cars per train, 65.

3. Average number of trains entering receiving yard in 24 hours, 10.

4. The average train pushed over the hump has 65 cars, and is handled with one engine weighing 135 tons. (Decapod, 0:10:0.)

5. Average number of cuts per train, 30.

6. Percentage of cars weighed that pass over hump, 3 per cent.

7. Cars are not uncoupled to be weighed.

8. The scale is located beyond the classification yard, and movement to reach it is made through that yard.

10. If the scale is not located on the hump, it should be placed to the side of the classification yard, on a track elevated about 3 ft. above the other tracks. This track should be about 400 ft. long, with an ascending grade to the scale, flat surface for the scale and 25 ft. beyond. Then a descending grade to the lead.

11. Two engines are used; one hump engine and one transfer engine.

12. The hump engine keeps the train moving continuously. However, when business is slack, the number of car riders is reduced, so that stopping to wait for riders is necessary.

13. The average and maximum classifying capacity of hump as determined by continuous operation is as follows:

One hour, 80 cars.
Five hours, 400 cars.
Ten hours, 800 cars.
One day, 800 cars.

14. One hour is allowed for meals; fires are cleaned during the meal hour.

15. The hump is actually in operation about 12 hours per day under normal operating conditions.

16. Three car riders are employed. They return singly to the hump. However, when doing maximum business, five riders are employed.

17. This number of car riders is sufficient to handle the average movement.

18. The proper number of car riders to employ to secure the greatest economy of operation is determined by the number of cars received.

19. The switches are operated by hand. One switchman is employed during slack time; two men when doing maximum business.

13. MISSOURI PACIFIC RAILWAY.

(East Bottoms Yard; Kansas City, Mo.)

1. Maximum number of trains entering receiving yard in one hour, 10.

2. Average number of cars per train, 40.

3. Average number of trains entering receiving yard in 24 hours, 36.

4. The average train pushed over the hump weighs 1,500 tons, and is pushed by one engine.

5. Average number of cuts per train, 25.

6. About 15 per cent. of the cars that pass over the hump are weighed.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump, 50 feet west of the summit.

11. There are 10 locomotives employed in the yard by day and five at night, as follows:

Day—1 in train yard (making up outbound trains); 1 at south hump (pulling receiving yard, putting over hump and shoving classification tracks); 1 at north hump (same as preceding); 1 at rip track (handling rip tracks, switching out bad-order cars, and switching for Mechanical and M. of Way Depts.); 1 switching to and from elevator; 1 in hold yard (switching hold tracks and industries); 1 at Sheffield industry and connections; 1 at brewery (industry); 1 handling stock from east yard to stock yards; 1 in receiving yard (works part of time in outbound train yard making up trains, and handles from receiving yard to hump; handles "hot stuff" direct to train yard).

Night.—One in train yard (making up outbound trains); 1 at north hump; 1 at south hump; 1 handling hold cars and elevator tracks; 1 handling stock from receiving yard to stock yards.

12. The hump engine keeps its train moving continuously at slow speed over the hump.

13. The classifying capacity of the hump is as follows:

	Maximum.	Average.
One hour	50	30
Five hours	250	150
Ten hours	500	300
One day	1,000	600

This is based on the use of one hump engine to pull up cuts, push cars over and shove up classification tracks.

14. One hour is allowed for meals. The fire is cleaned at the same time. The crews work 10-hour shifts. No time is necessary for changing engines and crews.

15. The hump is actually in operation 20 hours per day under normal operating conditions.

16. The number of car riders employed is 8 by day and 6 at night; total, 14. They walk back to the hump.

17. The number of car riders employed is sufficient to handle the average movement with nearly continuous operation.

18. The proper number of car riders is determined by checking the number of cars passing over hump.

19. The switches are operated by hand. Eight switches are assigned to one switchman.

20. No advantage can be gained by the use of two scales on the hump.

21. The cost per car for yard handling (from the time the road engine is cut off on the receiving track until the road engine is coupled on to the train on the departure track) is 27 cents.

14. NEW YORK CENTRAL RAILROAD.

(Yard at Avis, Pa.)

1. The maximum number of trains entering the receiving yard in one hour is 8. This was due to trains being bunched on the road by an accident, and following each other into the yard very closely.

2. Average number of cars per train, 60.

3. Average number of trains entering receiving yard in 24 hours, 20.

4. The hump engine weighs 76.25 tons; engine and tender, 122 tons. It pushes 65 cars in the summer and 40 in the winter. Two engines are never used.

5. Average number of cuts per train, about 70 per cent. of number of cars.

6. Percentage of cars weighed that pass over hump, 98 per cent.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump, about 80 ft. from summit. There is no other scale.

9. The classifying capacity of the yard is not diminished on account of scales being located on hump.

11. There are seven locomotives employed in the yard—one engine working on the hump, one in the classification yard, one in the empty yard (which is the southbound receiving yard), one pusher engine, one roustabout engine, one shop engine, and one at J. S. Junction yard. There are four engines on the night shift—one on the hump, one in the advance yard, one in the empty yard, and one pusher engine.

12. The hump engine keeps its train moving continuously at slow speed over the hump. No stops are made between cuts, unless it is necessary to stop and wait for the return of the car riders.

13. The average and maximum classifying capacity of hump as determined by continuous operation for given periods is as follows:

One hour, about 70 cars maximum and 38 cars average.
Ten hours, 620 maximum, 500 average.
One day, 1,100 maximum, 850 average.

14. One hour is allowed for meals, and one hour for changing crews. In times of extremely heavy business, one hour is allowed for meals and 35 minutes for changing crews.

15. The hump is actually in operation for 20 hours per day under normal operating conditions.

16. Four car riders are employed. They walk back to the hump.

17. The number of car riders employed is sufficient to handle the average movement of cars.

18. The proper number of car riders to employ to secure the greatest economy of operation is determined from the advance reports. The yardmaster knows what trains are on the road 12 hours before arrival and calls enough extra men to handle them if the movement is above normal. If the movement is greatly below normal, he lays off one or more riders for the day.

19. The switches are operated by hand. One man handles the throat switch and 8 ladder switches, which are all located within very short distance of throat. He also handles 6 or 7 switches back of the hump, and in doing this is helped out by the car riders.

21. The cost per car for yard handling (from the time the road engine is cut off on the receiving track until the road engine is coupled to the train on the departure track) averages 8.9 cents per car.

15. NEW YORK CENTRAL RAILROAD.

(Yard at West Albany, N. Y.)

1. Maximum number of trains entering receiving yard in one hour, 15. This includes trains from both directions.

2. Average number of cars per train: 35 cars per train from the east, 50 cars per train from the west.

3. Average number of trains entering receiving yard in 24 hours: 35 trains from the east, 29 from the west.

4. The hump engine weighs 76.25 tons, or 122 tons with tender. It pushes 45 cars over the hump.

5. Average number of cuts per train, about 80 cuts per 100 cars.

6. About 1½ to 2 per cent. of the cars weighed that pass over hump are weighed (or about 30 cars per day). This is all local freight from east of Amsterdam, with an occasional car taken from fast freight.

7. The cars are uncoupled to be weighed, as the track scales are not located on the hump.

8. The track scale is not located on the hump. Cars are pulled from the classification yard to the track scales and return by one movement.

11. The number of locomotives employed in the yard is 15 by day and 12 at night. They shift as follows: 2 in hump yard, 2 in lower end of eastbound classification yard, 1 in drop-pocket No. 4, 1 at the east end of the eastbound yard handling cabooses and helping trains, 1 at the transfer house, 1 at the coal trestle and enginehouse, 3 in the westbound classification yard, 1 in the local freight yard, 2 helping engines, and 1 at the Karner Yard. At night, cut out the Karner yard, local freight and coal trestle engines.

12. The hump engine keeps its train moving continuously at slow speed over the hump, except when stops are necessary for car riders to return.

13. The average and maximum classifying capacity of hump as determined by continuous operation for given periods is as follows:

One hour, maximum, 160; average, about 95.
Five hours, maximum, 500; average, 400.
Ten hours, maximum, 1,125; average, 800.
One day, about 2,000 maximum, and 1,600 average.

14. One hour is allowed for meals, and one hour for changing crews.

15. The hump is actually in operation 20 hours per day under normal operating conditions.

16. The number of car riders employed is 12 to 14 in each shift. They walk back to the hump.

17. The number of car riders employed is sufficient to handle average business with continuous operation of the hump.

18. Enough riders are employed to handle the average movement. From advance information, if it is seen that business will be extremely heavy, enough extra riders are employed. If business is extremely light, some riders are laid off.

19. The switches are operated by hand. One man at the throat operates the throat switch and four switches back of the hump. The other switchmen operate from 5 to 8 each.

21. The cost per car for yard handling (from the time the road engine is cut off on the receiving track until the road engine is coupled to the train on the departure track) averages about 28 cents per car.

16. NEW YORK CENTRAL RAILROAD.

(DeWitt Yard, near Syracuse, N. Y.)

1. Maximum number of trains entering receiving yard in one hour, five trains in each direction.

2. Average number of cars per train, 70; fast freight, 50; slow freight, 75 to 85.

3. Average number of trains entering receiving yard in 24 hours: 50 from the west, 35 from the east.

4. The engines weigh 135 tons, 210 tons with tender. One engine will push 40 cars over the hump; two engines will push 85 cars weighing 3,300 to 3,400 tons.

5. The average number of cuts is from 35 to 50 cuts per train, or an average of about two-thirds the number of cars for westbound movements. Eastbound movements average about 35 cuts per train.

6. Only about 4 or 5 cars of local freight are weighed each day; this is all local freight from west of Oneida.

7. Cars are uncoupled to be weighed. There is no hump scale in this yard.

8. The scale is located in the eastbound freight yard, but is not in use. Local freight is sent to Syracuse to be weighed. This only amounts to about 3 cars per day.

11. There are 16 engines on each shift, as follows: Three hump engines (two of them on eastbound hump, and one on westbound hump); 1 kicker engine in westbound yard; 2 shop engines; 2 engines in caboose yards; 1 engine in each of the fast freight yards; 1 engine in westbound local yard, and 4 roustabout engines; 1 engine around coaling plant, also used for making Syracuse deliveries.

12. The hump engine keeps the train moving continuously at slow

speed. Stops are made only when necessary to wait for hump riders to return.

13. The classifying capacity for both humps, as determined by continuous operation, is as follows:

	Maximum.	Average.
One hour	300	200
Ten hours	2,783	2,000

One day, no figures for maximum, but about 5,000 maximum; average, about 4,000.

14. One hour is allowed for meals, and one hour for changing crews.

15. The hump is actually in operation 20 hours per day under normal operating conditions.

16. There are 20 to 35 hump riders, generally 24 on each shift. They return to the hump by walking.

17. The number of car riders employed is sufficient to handle the average movement.

18. The proper number of car riders to employ is determined from advance reports of business coming into the yard. If reports show heavy business, riders sufficient to put the cars through the yard are employed. If business is extremely light the number is reduced.

19. The switches are operated by hand, and from one to eight switches are assigned to each switchman. The man at the throat switch operates one switch only. The next two men operate 3 each; the next four men operate 5 and 6 each. In the advance and caboose yards, switchmen operate about six switches each; switchmen are stationed also at each end of the receiving yards, and one at the middle of the eastbound receiving yard.

21. The cost per car for yard handling (from time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is about 10¼ cents per car.

17. NORFOLK & WESTERN RAILWAY.

(Yard at Williamson, W. Va.)

1. Maximum number of trains entering receiving yard in one hour, 11.

2. Average number of cars per train, 60.

3. Average number of trains entering receiving yard in 24 hours, 24.

4. One 90-ton engine will push an average train of 30 cars over the hump. Two engines will push 65 cars.

5. Every car in the train is cut.

6. About 95 per cent. of the cars that pass over hump are weighed.

7. The cars are uncoupled to be weighed.

8. The scale is located on the hump, 75 ft. from the summit.

9. Classification is facilitated by locating the scale on the hump.

11. Five locomotives are used, all assigned to classifying cars.

12. The hump engine does not keep its train moving continuously, but stops are made between cuts.

13. The classifying capacity of the hump as determined by continuous operation is as follows:

One hour, 40 cars.
Five hours, 180 cars.
Ten hours, 300 cars.
One day, 350 cars.

14. One hour at noon and midnight is allowed for meals and for changing engines and crews, cleaning fires, etc.

15. The hump is actually in operation 12 hours per day under normal operating conditions.

16. There are 10 car riders. They walk back to the hump.

17. The number of car riders employed is sufficient to handle the average movement.

19. The switches are operated by hand; 10 switches are assigned to one switchman.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 11 cents.

18. NORFOLK & WESTERN RAILWAY.

(Gravity Yard at Bluefield, W. Va.)

1. Maximum number of trains entering receiving yard in one hour, 7.

2. Average number of cars per train, 30.

3. Average number of trains entering receiving yard in 24 hours, 24.

4. One 90-ton engine handles 30 cars over the hump. Two engines are used only in emergency.

5. Every car weighed is cut.

6. About 80 per cent. of cars that pass over hump are weighed.

7. Cars are uncoupled to be weighed.

11. Four engines are used each 24 hours, 2 of which are used to weigh and classify (one, however, on the empty side movement, which is not included in average and maximum figures) and 2 that handle passenger, shop track work, switch out loads for city delivery, set out loads not consigned, loads awaiting consignment, freight station work, etc. We have only the one engine that weighs the loaded cars included in this movement as outlined. Only one engine works on the hump with the loaded cars; the making up of the loaded trains is effected by an assorting process, and train is completed by dropping by gravity from the assorting yard to yard further on, known as the "east running" or train yard. The scale or hump engine is only required occasionally when a coupling fails, car damaged, or some irregularity arises, this being part of the duty of the scale or hump engine.

12. The hump engine keeps its train moving continuously.

13. The classifying capacity of the hump as determined by continuous operation is as follows:

	Average.	Maximum.
One hour	30 cars	110 cars
Five hours	150 "	265 "
Ten hours	300 "	500 "
One day	720 "	1,240 "

14. One hour is allowed for meals each 12 hours. The engine's fire is cleaned once each 24 hours, the cleaning being done during one of the meal hours allowed. Change of crews is made in the yard, and no time is allowed therefor.

15. The hump is actually in operation for 20 hours per day under normal operating conditions.

16. There are 16 car droppers with each engine 12 hours. They walk back to the hump.

17. The number of car riders employed is sufficient to handle the average movement with nearly continuous operation.

18. The proper number of car riders to employ is determined by anticipating the number of cars that should be received in the future 12 hours.

19. The switches are operated by hand. There is one switchman to every four switches.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is about 20 cents per car.

19. PENNSYLVANIA RAILROAD.

(Yard at Altoona, Pa.)

1. Maximum number of trains entering receiving yard in one hour, 10.

2. Average number of cars per train, 38.

3. Average number of trains entering receiving yard in 24 hours, 90.

4. Average train pushed over hump with one engine, 76 cars, 4,800 tons.

5. Average number of cuts per train, 1⅓.

6. Percentage of cars weighed that pass over hump; Juniata scales, 90 per cent.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump at "JS" tower, 30 ft. from the summit.

9. At Juniata scales the cars are weighed and classified at one and the same time, which diminishes the capacity of shifting about 20 per cent.

10. Only the make up of the yard and the nature of the business can determine the question as to where the scale should be, if not on the hump.

11. There are 15 engines in the eastbound yard, each of which has its regularly assigned duties, such as pushing trains over the humps, making up trains for the road and delivering them to the advance tracks for air inspection and test, delivering cars to individual sidings in specified districts, as well as performing miscellaneous duties throughout the yard.

12. The hump engine keeps its train moving continuously over the hump at a speed of approximately two miles per hour. Stops are made only for the return of car riders, which (as a rule) does not occur more than once during the classifying of an 80-car train.

13. The classifying capacity of the hump as determined by continuous operation is as follows:

	Average.	Maximum.
One hour	100 cars	120 cars
Five hours	500 "	604 "
Ten hours	1,000 "	1,034 "
One day (20 hours)	2,000 "	2,240 "

14. One hour is allowed train crews for meals, at which time the engines are placed on the pits to have fires cleaned, and at the same time to get coal and water and oil, also other necessary supplies. The engineman and fireman remain with the engine during this time, for which time is allowed.

15. The hump is actually in operation approximately 16 hours out of each 24.

16. There are 18 car riders or brakemen each at "JS" and "WN," making a total of 36 car droppers in the eastbound yard. These men are hauled back to the hump in a pickup car operated by a light engine on a track provided for this purpose. This track is kept clear at all times for the movement of the pickup car in either direction. The track is located at the extreme north side of the yard, which enables the car to be run up alongside the hump without interfering with the hump operations. A track of this kind would undoubtedly be preferable in the center of the yard if it were not for the interference at the hump.

17. During prosperous times a sufficient number of riders are employed to handle the business promptly in a limited time, six hours being considered a reasonable amount of delay to a car from the time it arrives, is inspected, classified, made up in a train and despatched, actually leaving the yard. With the present depression only a sufficient number of car riders is employed to handle the average movement with nearly continuous operation of the hump.

18. A check on the car riders is used to determine the number of cars and cuts each rider is capable of riding for the entire day, the average being about 28 cuts in 12 hours for each car dropper. In this way it is possible to determine the number of car droppers to assign to each hump in order to economically control the amount of business in sight. The assignment of car droppers to the various humps is

flexible, which enables the number to be varied for each 10 or 12 hour period, according to the amount of business in sight.

19. All the switches in use on the various hump operations at Altoona are direct movement electro-pneumatic, operated by a man in a tower by the use of a push-button machine.

20. The only advantage to be gained by two scales on a hump is where there is a sufficient amount of business to require a continuous operation, so that in the event of one scale being out of service for any cause (such as break down, or the drop bottom of a car coming loose and the load falling on the scale) the work can be immediately operated over the second or emergency scale and the weighing continued. For illustration, at the Juniata scales (Altoona) the two scales are side by side on the descending side of the hump. The yard weighs approximately 1,600 cars at this point each 24 hours, and the business would undoubtedly suffer greatly if there were but one scale, as the yard would not be prepared to continue the operations for several hours while repairs are being made to the scale. The second scale is merely an emergency scale, and only one scale can be operated at a time. The scales should be placed side by side 30 ft. beyond the apex of the hump on the descending side, with the necessary connections at either end to admit of using either scale from one and the same receiving yard and the same classification yard. This layout is regarded by the scale inspector as being an ideal arrangement.

21. Cost per car for yard handling from time the road engine is cut off on receiving track until road engine is coupled to train on departure tracks. During May, 1908, the cost per car at "WN" where there is no weighing done, was 13.7 cents and 23.1 cents per cut. At Juniata scales during the same month it was 14.4 cents per car and 35.2 cents per cut. The difference in the cost at the two points is due to the fact that at Juniata scales each and every car is cut apart to be weighed and ridden over the scales by a car dropper. There are no figures at hand showing the cost per car from the time they enter the yard until they are coupled to the road engine outbound, but the above figures will nearly show the cost from the time they are moved from the receiving yard until they are classified ready to be made up into trains.

20. PENNSYLVANIA RAILROAD.

(Yard at Enola, Pa. See Figs. 19 and 20.)

1. Maximum number of trains entering receiving yard in one hour, 7 eastbound and 9 westbound.

2. Average number of cars per train, 50 cars per train eastbound and 45 cars per train westbound.

3. Average number of trains entering receiving yard in 24 hours, 33 trains eastbound and 38 westbound.

4. The average train pushed over the hump has 68 cars (3,800

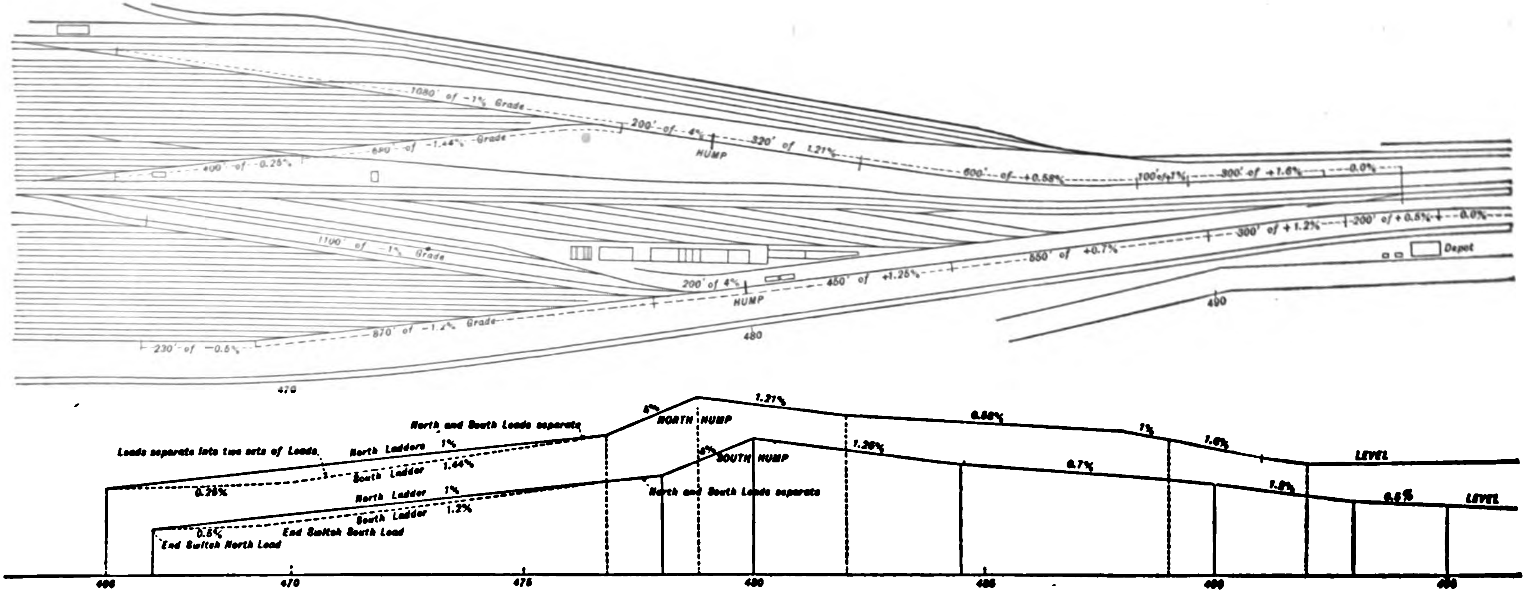


FIG. 18. PLAN AND PROFILE OF HUMP FREIGHT YARD AT COLLINWOOD, O.; L. S. & M. S. RY.

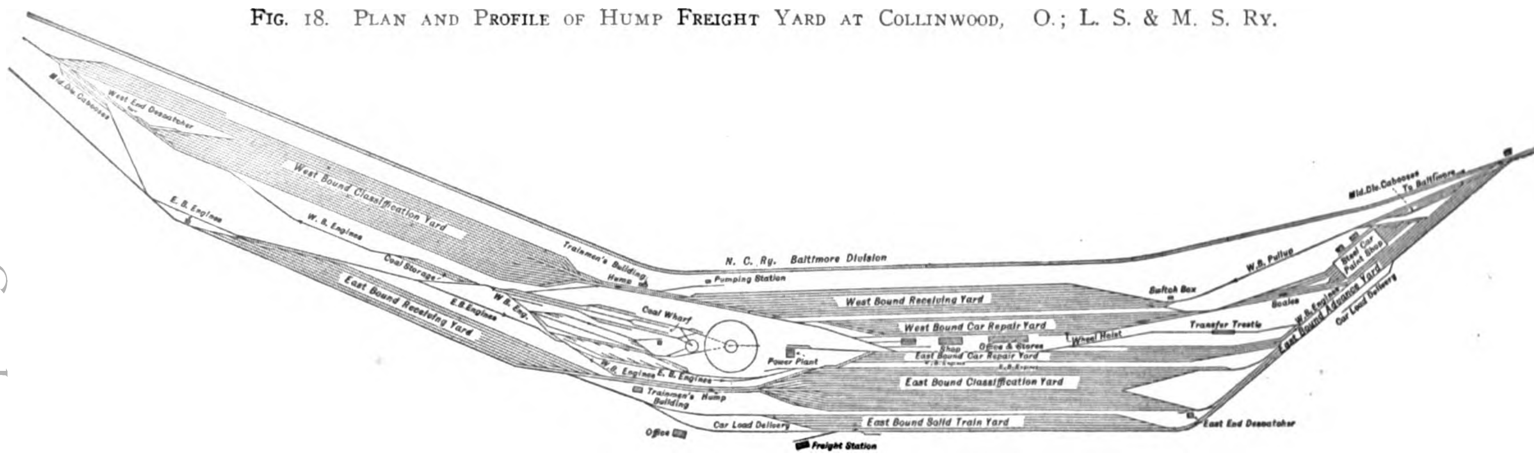


FIG. 19. PLAN OF HUMP FREIGHT YARD AT ENOLA, PA.; PENNSYLVANIA R. R. (FOR PROFILE SEE FIG. 20.)

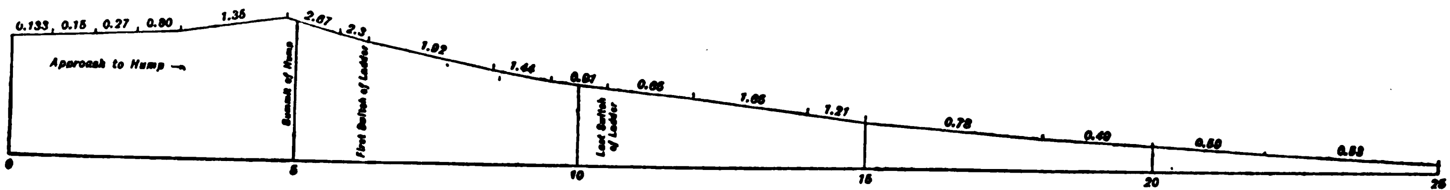


FIG. 20. PROFILE OF EASTBOUND HUMP AT ENOLA, PA.; PENNSYLVANIA R. R. (FOR PLAN SEE FIG. 19.)

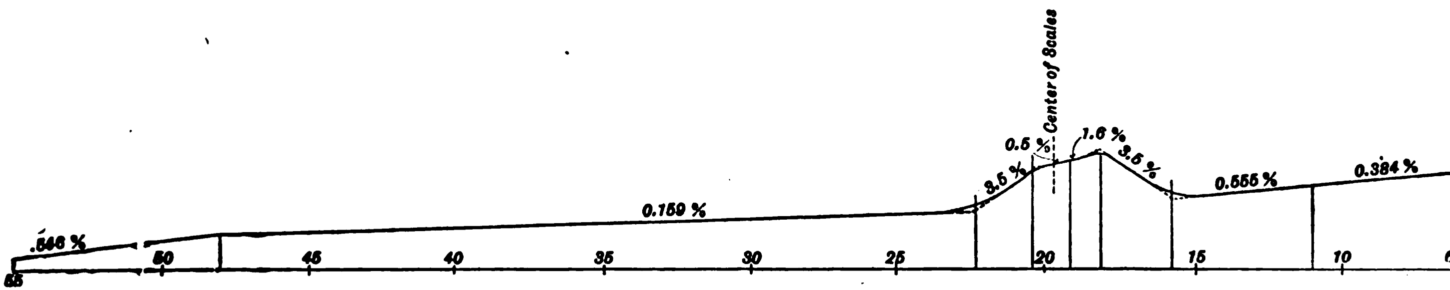


FIG. 21. PROFILE OF HUMP OF YARD AT TERRE HAUTE, IND.; VANDALIA RY.

tons). Only one pusher engine is used in handling some trains, but with the majority of trains it is necessary to assist the pusher engine with a pole by getting alongside the trains to be shifted. Two engines are used only in extreme cold weather, when two engines are coupled together.

5. Average number of cuts per train, 25 cuts eastbound and 29 cuts westbound.

6. The scales in the yard are not located on the hump.

7. Cars are uncoupled to be weighed.

8. The scales are located at the extreme east end of the yard, just east of the shops. To reach them requires a regular movement.

9. The amount of weighing is so very small that it does not interfere to any great extent with the work. Cars are cut out from trains to be classified and weighed with engine located at east end of yard.

10. The make up of the yard and the nature of the business only can determine the question as to the location of the scale.

11. In the yard there are 2 engines for eastbound trains and 2 for westbound trains, which are used for hump work exclusively. Also one engine eastbound and one westbound, located at the shops, and one engine at eastbound and westbound ends of the yard, making up trains and classifying cars.

12. The hump engine does not keep its train moving continuously at slow speed. Stops are made after draft riders are all cut off from train until they return.

13. The classifying capacity of the hump as determined by continuous operation is as follows:

	Eastbound.		Westbound.	
One hour	81 cuts		108 cuts	
Five hours	291 "		389 "	
Ten hours	580 "	1,318 cars	688 "	1,396 cars
One day (24 hours)....	900 "	2,151 "	1,205 "	2,488 "

14. One hour is allowed for meals and for changing engines and crews, cleaning fires, etc.

15. The hump is actually in operation 15½ hours out of each 24 hours.

16. There are 15 car riders employed.

17. This number of car riders is only sufficient to handle the average movement.

18. The proper number of car riders to employ to secure the greatest economy of operation is determined by keeping a close watch on the reports of trains moving toward the yard from the different divisions.

19. The switches are operated by air. One man is assigned to this work on each hump.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 10 cents.

Notes.—The eastbound yard consists of a receiving and classification yard for loaded cars, most of which are despatched over the low grade freight line to Trenton, the remainder leaving the low-grade freight line at Glen Loch and going into Philadelphia yard.

The westbound yard consists of a receiving and classification yard for empty cars going west for distribution.

Enola yard is located on the east side of the Susequehanna river, opposite Harrisburg yard, and relieves Harrisburg yard to a considerable extent.

21. PENNSYLVANIA LINES (Northwest System).

(Conway, Pa.; Eastbound Yard No. 4.)

1. Maximum number of trains entering receiving yard in one hour, 12.
2. Average number of cars per train, 45.
3. Average number of trains enter receiving yard in 24 hours, 25.
4. Two engines are used to the hump train. They push 55 cars over the hump (3,500 tons).
5. Average number of cuts per train, 20.
6. Percentage of cars weighed that pass over hump, 5 per cent.
7. Cars are uncoupled to be weighed.
8. The scale is located on the hump, 300 ft. from the summit.
9. The classifying capacity of the yard is not diminished by this location of the scales, considering that if located elsewhere the cars to be weighed must be switched out, weighed, and then classified.
11. Five engines are used: Two are used in making up trains in classification yard, one ("snapper engine") shoving tracks, returning car riders, etc.; and two shoving trains over the hump.
12. The hump engine keeps its train moving continuously at slow speed over the hump.
13. The classifying capacity of the hump, as determined by continuous operation, is as follows:

	Average.	Maximum.
One hour	63	90
Five hours	295	425
Ten hours	550	810
One day	1,060	1,450

14. One hour is allowed for meals; 45 minutes for changing engines and crews, including time for changing to relief engine when one in use is relieved for cleaning fire, coaling, etc.
15. The hump is actually in operation 19 hours per day under normal operating conditions.
16. There are 20 car riders. They are returned to the hump by snapper engine (see No. 11).
17. The number of car riders employed is sufficient to handle all

the cars that can be drilled before the "snapper" engine is required to clear the ladders and shove tracks.

18. The proper number of car riders to secure the greatest economy of operation is governed by the maximum number of cars that can be cut off in one round without stopping the hump engines, and by the number of trains received per hour.

19. The switches are operated by hand. Eight switches are assigned to one switchman.

20. Having two scales on a hump makes it practicable to have a winter and a summer hump, the winter hump having steeper grades. Repairs can be made to scales without stopping operations on the hump.

21. The cost per car for yard handling (from the time the road engine is cut off on the receiving track until the road engine is coupled to the train on the departure track) is 18 cents.

22. PENNSYLVANIA LINES (Southwest System).

(Information covering nine hump yards.)

The following information is given for nine hump yards on the Southwest System. In some cases only one hump is located at one point. In others there are two, one being eastbound and the other westbound.

The average number of cars in 24 hours over single humps runs about as follows: 1,064, 1,286, 600, 900, 600, 700, 800.

The maximum number of cars over a single hump in 24 hours, at different points, is 1,296, 1,348, 1,100, 1,440, 1,200, 1,400, 1,500.

In only one of these yards are two engines regularly employed. All of the others have one engine in the day and one engine at night. In some a second engine is employed in severe weather and during very heavy business. When a single engine is employed, it is placed at the rear of the train and pushes a string of cars over the hump. When a second engine is employed it is usually placed alongside of the ladder and assists in pushing stopped cars into the classification yard. It has been found exceedingly important to keep the classification yard switches as close to the hump as possible; otherwise, the second engine becomes inevitable, and increases the cost of switching.

Many records have been taken of the actual time consumed in switching cars, and it has been found to run as follows, in different yards, according to the distance of the classification yard switches from the hump. The following figures are per car:

1 min. 51 secs.	1 min. 2 secs.
1 " 8 "	57 "
1 " 4 "	54 "

As a matter of fact, while switching is actually going on, the time of switching is only from 23 to 34 per cent. of the total time consumed. If, therefore, the time consumed per car for switching is 54 seconds, it

would be possible to put over the hump 1,600 cars in 24 hours. It will be seen that the records given above for maximum switching are fair. One of our superintendents estimates he can even put 2,000 cars over a hump in 24 hours.

There is one scale located on the hump in nearly all of these yards. In some cases a run-around or dead track is provided, if the cars to be weighed are a small proportion of the total cars switched. In one yard we have duplicate scales, side by side, all of the cars switched being weighed. Only one is used at a time; the other is held in reserve for use while repairs are being made to the first.

Our transportation officers are of the opinion that where 5 per cent. of the cars switched are to be weighed, a scale should be placed on the hump. In cases where the percentage is small, a dead track or run-around track must be provided for switching without weighing, the run-around track being preferable to the dead track, so as not to interfere with switching when repairs are being made on scales. The head car is stopped on the hump, after passing the scale, and a cut of several allowed to accumulate with it, before the entire cut is allowed to start again for the classification yard. This saves riders.

With reference to switching by cable; some consideration has been given to the matter, but it does not look at present to be reasonable, because of the time lost in waiting for the dummy car to be hauled back to the beginning of the track in order to engage another train.

23. PHILADELPHIA & READING RAILWAY.

(Yard at Rutherford, Pa.)

The Committee presents the following information as to operation of the humps in this yard, which was mentioned and illustrated in the report of last year. In addition to the information as listed below, some additional particulars are given.

For instance, trains of 16 or 17 cuts are classified in from 5 to 7 minutes, but if there are more cuts in the train it becomes necessary to wait for men to ride the cars. It will be noted, therefore, that some trains are classified at the rate of more than 400 cars per hour. Classification at the rate of 300 cars per hour is accomplished daily, and if the supply of cars could be kept reasonably uniform this rate of classification could be made practically continuous over a well designed hump by using a sufficient number of engines and men.

It will be noted also that the scale is not on the hump. The percentage of cars to be weighed is very small at this place. There is no hump where most of the coal is weighed, but there is a gravity yard with ideal grades both above and below the scale. Here 150 cars per hour are weighed with great ease; all of the work is done by hand and with cars running sometimes at rate of 10 miles per hour over a scale 60 ft. in length.

No record of hourly performance has ever been kept at Rutherford, but they have classified a few more than 1,500 cars in a calendar day with four hours off duty (6 a. m. to 7 a. m., 6 p. m. to 7 p. m., and at noon and midnight). They have classified more than 900 cars on one 12-hour period (with 2 hours off duty, as stated above), thus making a 10-hour average of 90 cars per hour. These results are far below what could be accomplished if the hump could be kept constantly employed.

1. Maximum number of trains entering receiving yard in one hour, 5.

2. Average number of cars per train, 44.

3. Average number of trains entering receiving yard in 24 hours, 30.

4. The average train pushed over hump has 44 cars (2,500 tons). It is handled with two engines, weighing 83 tons.

5. The average number of cuts per train is 29.

6. Only 0.5 per cent. of the cars that pass over the hump are weighed.

7. The cars are not uncoupled to be weighed.

8. The scale is located on the approach to the hump, but on a separate track. Cars to be weighed are dropped back on scale.

10. The scale should be on the hump, and as close to its apex as possible.

11. There are 6 locomotives employed in yard; 2 on each hump, 1 in each yard.

12. The hump engine keeps its train moving, except when stopped awaiting return of car riders.

13. The classifying capacity of one hump, as determined by continuous operation, is as follows:

> One hour, 150 cars; Five hours, 600; Ten hours, 900; One day (20 hours on duty), 1,500 cars. Frequently classify at the rate of 300 cars or more per hour.

14. One hour in each trick of 12 hours is allowed for meals, and for changing engines and crews, cleaning fires, etc.

15. The hump is actually in operation about 12 hours in a calendar day, under normal operating conditions.

16. There are 17 car riders employed on the eastbound side (23 classification tracks); 12 on the west side (11 tracks).

17. The number of car riders employed is sufficient only to handle average movement.

19. The switches are operated by hand, 3 to 7 to a switchman.

20. No advantage can be gained by the use of two scales on a hump, except in case of breakdown. It is better to keep duplicate parts. If placed, they should be close together and opposite.

24. PITTSBURG & LAKE ERIE RAILROAD.

(Yard at Hazelton, Pa.)

1. Maximum number of trains entering receiving yard in one hour, 5.

2. Average cars per train, 65.

3. Average number of trains entering the receiving yard in 24 hours, 22.

4. The average train pushed over the hump has 45 cars of 100,000 lbs. capacity. One 90-ton engine is used.

5. Average number of cuts per train, 25.

6. None of the cars are weighed on the hump.

8. There are no scales.

11. Three locomotives are employed; one for shoving cars over the hump; one for bringing the car riders back; one for switching out cars with defective brakes after train is made up.

12. The engine keeps its train moving continuously over the hump.

13. The classifying capacity of the hump is as follows:

	Average.	Maximum.
One hour	70 cars	100 cars
Five hours	350 "	500 "
Ten hours	700 "	1,000 "
One day	1,400 "	2,000 "

14. One hour is allowed for meals and cleaning engine fires.

15. The hump is actually in operation about 20 hours out of the 24.

16. Seven car riders are employed; they walk back or ride on the engine provided for the purpose.

17. This number of riders is sufficient only for the average movement.

18. The number of car riders to be employed is determined by keeping in touch with connections, and figuring how many cars will be moved.

19. The switches are operated by hand; 16 switches to one man.

21. The cost per car for yard handling (from the time the road engine is cut off on the receiving track until the road engine is coupled to the train on the departure track) averages 9 cents.

25. SOUTHERN RAILWAY.

(Asheville, N. C.; West and East Receiving Yards.)

1. Maximum number of trains entering receiving yard in one hour, 4.

2. Average number of cars per train, 30.

3. Average number of trains entering receiving yard in 24 hours, 20.

4. The average train pushed over the hump by one engine (weighing 235,050 lbs.) has 30 cars, or 1,200 tons. Two engines are not used.

5. Average number of cuts per train, 15.

6. About 10 per cent. of the cars that pass over the hump are weighed.

7. Cars are uncoupled to be weighed.

8. The scale is located on the hump, 50 ft. from the summit.

9. With the scale located on the hump, the classifying capacity of the yard is not diminished.

11. Two engines are employed by day, and two at night. One works on the humps. The other does city business and handles passenger equipment.

12. The hump engine keeps its train moving continuously at about 3 miles per hour.

13. The classifying capacity of the hump, as determined by continuous operation for certain periods is as follows:

One hour, 80 cars.
Five hours, 400 cars.
Ten hours, 800 cars.
One day, 1,000 cars.

14. One hour is allowed for meals and for changing engine, crews, cleaning fires, etc.

15. The hump is actually in operation 20 hours in a calendar day under normal operating conditions.

16. The number of car riders employed is five by day and six at night. They walk back to the hump.

17. The number of car riders employed is only sufficient to handle the average movement.

18. The number of car riders employed is regulated as business increases or decreases.

19. The switches are operated by hand. Four to one man and six to another.

20. For this yard, we do not see that any material advantage would be gained by the use of two scales on a hump.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until the road engine is coupled to train on departure tracks) is 4⅞ cents.

26. TERMINAL RAILROAD ASSOCIATION OF ST. LOUIS.

(Westbound Yard; East St. Louis, Ill.)

1. Maximum number of trains entering the receiving yard in one hour, 3.

2. Average number of cars per train, 40.

3. Average number of trains entering receiving yard in 24 hours, 25.

4. The average train pushed over hump has 25 cars (500 tons).

5. Average number of cuts per train, 12.

6. None of the cars are weighed that pass over hump. There is no scale in the yard.

11. There is one engine on the hump (day and night).

12. The hump engine keeps its train moving continuously.

13. The classifying capacity of the hump, as determined by continuous operation, is as follows:

One hour, 100 cars.
Five hours, 500 cars.
Ten hours, 1,000 cars.

Greatest number of cars actually switched over the hump in a day of 24 hours, 1,400.

14. One hour is allowed for meals, and for changing engines and crews, cleaning fires, etc.

15. The hump is actually in operation 20 hours per day under normal operating conditions.

16. There are 7 car riders (returning on foot), 4 switch tenders, 1 foreman; total, 12 men, in addition to engine crew.

17. The number of car riders employed is only sufficient to handle the average movement, with nearly continuous operation of the hump.

18. The proper number of car riders to employ is determined by the volume and nature of business handled from day to day, from a forecast given the general yardmaster at 6 a. m. and 6 p. m. each day.

19. Each switchman operates five switches, by hand.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is from 8 cents to 10 cents per car. This cost includes only actual yard handling, that is, time of switching, engine crew and fuel, water and supplies for the switching engine.

27. VANDALIA RAILROAD.

(East Yard; Terre Haute, Ind. See Fig. 21.)

1. Maximum number of trains entering receiving yard in one hour, 12.

Eastbound receiving yard, 5 tracks, one running track.
Westbound receiving yard, 12 tracks, one running track.
Michigan Division receiving yard, 7 tracks, 1 running track.
Classification receiving tracks, two tracks.

2. Average number of cars per train, 19 (900 cars received per 24 hours).

4. Trains of 30 cars average 1,000 tons. Small trains are doubled up in the receiving yards by the hump engine for hump classification, in order to facilitate yard movement to hump. The train is handled by one engine weighing 225 tons. Two engines are used to push cuts over the hump only in extremely cold weather.

5. There is an average of 12 cuts per train.

6. About 10 per cent. of the cars that pass over the hump are weighed.

7. Cars are uncoupled to be weighed.

8. The track scale is automatic, and is located one car length from summit or top of incline. There is a spring split switch at the leading end. Cars are weighed without retarding the movement in classification.

10. The scale should always be on the hump, unless the proportion of cars to be weighed is very small. It then should be located on the low end of a classification track, into which the cars to be weighed can be dropped or so that it can be conveniently reached from such a track.

11. Two engines are in service in the hump yard, known as first and second hump engines. Both are used to deliver cars to the hump, classifying same, shoving tracks, and building or making up trains for outbound movement. All outbound trains depart from the classification yard.

12. Trains are moved over the hump at a speed not to exceed three miles per hour. Stops are made to allow riders to return to hump, and for inspection of brakes and under rigging, etc., on cars found with defective brakes or carded as such. The hump conductors direct inspection or test of brakes.

13. The average classifying capacity of the hump is three switches or cuts per minute. The maximum classifying capacity of the hump is limited only by the number of car riders available and ability to relieve classification yard of cars.

14. One hour is allowed crews for meals, except when there is a crowded yard or occasion to keep crew in continuous service. In such case they are given from 15 to 20 minutes to eat and are allowed the hour. Engines in humps and classification yards are relieved from service at the end of each day and night by a fresh or relief engine from the roundhouse, which is properly coaled, watered, etc., ready for service. The relief engineman returns to the house with the first engine exchanged. This is cleaned and returned to the yard, relieving the second engine, and so on. The first relief engine also handles a coach from city to yards for convenience of enginemen, trainmen and yardmen changing shifts.

15. The hump is in actual operation 18 hours per calendar day under normal operating conditions.

16. There are eight car riders employed by day, and six at night. They walk back to the hump.

17. The number of car riders employed is only sufficient to handle the average movement with nearly continuous work for the hump engine.

19. There are two switch tenders by day and night, operating from the hump and what is known as "in the field," respectively. The hump switch tender handles three switches, directing movement of cars to as many ladders, and assists in lining switches around hump for outgoing trains. The "field" switch tender has some 25 switches to look after.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 8 cents.

28. WASHINGTON SOUTHERN RAILWAY.

(Potomac Yard; north of Alexandria, Va.)

1. Maximum number of trains entering receiving yard in one hour: northbound, 5; southbound, 7.

2. Average number of cars per train: northbound, 21.96; southbound, 20.91.

3. Average number of trains entering receiving yard in 24 hours: northbound, 32.51; southbound, 28.87.

4. The average northbound train pushed over the hump has 20 loads and 2 empties, 840 tons. Southbound, 6 loads and 14 empties, 520 tons. One engine is used on each hump, 120 tons.

5. Average number of cuts per train: northbound, 15.14; southbound, 13.65.

6. Percentage of cars weighed that pass over hump, northbound, 18.43 per cent.

7. Cars are uncoupled to be weighed.

9. The classifying capacity of the yard is not diminished by scale located on the hump.

10. The scale should be located on the hump.

11. There are five locomotives by day and six at night. One locomotive classifying trains on the northbound hump; one classifying trains on the southbound hump. One at the north end and one at the south end of the yard making up trains, switching out cars that have been shopped, and other work of this character. One doing general yard work, placing coal on the coal wharf, removing the loaded and placing empty cars at the ash track, placing loads and removing empties from the storeroom track, placing coal on the power house siding, switching cars in and out of the shop yard, bulk transfer, and less-than-carload transfer station. One (at night) placing loads and removing empties from outlying sidings outside of the yard proper, such as serving industries and local freight station.

12. The hump engine keeps its train moving continuously, but stops are made when the car riders are exhausted.

13. The best results are obtained with the movement at a speed of two miles per hour passing the summit. At this speed, three cars per minute would pass that point, everything being in balance. In practice, this number is diminished by reason of adjusting brakes, cut levers not operating properly, mistakes made in preparing switching list, switch tenders making mistakes in getting the cars on the wrong tracks, cars stalling before entering the classifying tracks by reason of the riders applying the brakes, or brake hanging, or other causes.

14. Two hours are allowed for meals, one at noon, the other at midnight. From 20 to 30 minutes are lost in changing from day to night force, and from night force to day force. No time is lost by reason of cleaning fires, as the engines are sent to the ash track at

the time the crews are stopped for meals. The engine crew, however, is allowed time for taking the engine to and from the ash track.

15. The humps are in actual operation for the 24 hours, excepting during the midnight and noon meal hours; also at 6 a. m. and 6 p. m., when forces change, and when awaiting return of car riders.

16. There are 7 car riders employed for the northbound hump, and 6 for the southbound. They walk back to the hump.

17. The number of car riders employed is sufficient to handle the average movement with nearly continuous operation of the humps.

18. The regular number of car riders is put out daily; this was determined by the minimum day's business. At 4 a. m. and 4 p. m. the situation is canvassed as to the probable run for the following twelve hours, and additional car riders are put out at 6 a. m. and 6 p. m. to meet any abnormal run.

19. Switches are operated by hand. The number of switches assigned to one switchman is governed by the number of cuts, and location of switches.

20. If two scales were located at the same distance from the summit on the hump, one at a higher elevation than the other, and their use governed by weather conditions, this would be an advantage. The receiving and classifying yards could be so arranged with two scales on the summit that two trains could be classified at the same time.

21. The cost per car for yard handling (from the time the road engine is cut off on receiving track until road engine is coupled to train on departure track) is 32.4 cents. This is based on the wages of the following employés: Enginemen, firemen, conductors, flagmen, brakemen, switchtenders, yardmasters, assistant yardmasters, yard clerks, yard messengers.

NOTE.—GRADES OF HUMPS IN PEN HORN YARD OF ERIE RAILROAD.
(See pages 45 and 46.)

North Hump.			South Hump.		
	Grades, per cent.	Length, feet.		Grades. per cent.	Length, feet.
Yard (ascending)	0.02	....	Yard (ascending)	0.01	....
Ascending	1.38	50	Ascending	0.98	100
Ascending	2.62	50	Ascending	2.40	75
Ascending	0.72	50	Ascending	2.81	125
Ascending	2.68	275	Ascending	0.90	50
Descending	1.12	25	Descending	2.10	200
Descending	2.97	75	Descending	1.22	200
Descending	1.62	250	Yard (descending)	0.017	......
Descending	1.24	75	Total length of hump	....	750
Descending	0.94	225	Total rise of hump	....	6.65
Descending	0.46	275			
Yard (descending)	0.013	....			
Total length of hump	....	1,350			
Total rise of hump	....	10.89			

Appendix B.

OPERATION OF THE GALESBURG YARD: CHICAGO, BURLINGTON & QUINCY RAILWAY.

(From a paper read before the Burlington Association of Operating Officers by J. W. Mulhern.)

As is well known, the railway owners of Western trunk lines have not until the last few years given the matter of enlarging division yards and terminal facilities the consideration they justly deserve for the expeditious and economical handling of the fast-growing traffic.

Probably there is no division point on any railroad in the West, surely none on the C., B. & Q., where improved switching facilities are more necessary than at Galesburg, where trains are received from and made up for forwarding in eight different directions. This necessity, however, has been clearly recognized by our present management, with the result that we have now nearing completion, and in full operation, what to most of us on the Burlington System is a new type of yard, commonly called a "double hump yard." This is nothing more than two separate yards, so arranged as to permit of free interchange of cars with the minimum amount of switching, so essential where there are so many diverging routes, as above indicated.*

A hump yard is one in which the movement of a car is produced by pushing it over a summit, beyond which it runs by gravity. A train of cars to be separated and classified is pushed out of the receiving yard to the summit of the hump, where each car, or cut of cars, is boarded by a rider, or switchman, who tests his brakes. The car, or cut of cars, being uncoupled, acquires a speed on the downgrade that carries it over the frogs and switches onto the proper track in the classification yard without further assistance, the rider so controlling the car (or cut of cars) as to stop it at the desired point, so as to prevent damage by the cars being run together at too high a rate of speed.

The new Galesburg yards are designed as "eastbound" and "westbound" humps. The eastbound yard is comprised of a receiving yard from the south and west, with six receiving tracks of a capacity of 480 cars. This receiving yard is built on a grade of 0.3 per cent., beginning at the entrance, and running 3,675 ft., where we get a level for 1,400

*A plan of this yard is given in Fig. 16. Details of its operation are given on page 285.

ft., which brings us to the base of the hump. Then there is 575 ft. of 1.1 per cent. grade, and then 75 ft. of vertical curve, which carries cars easily over the hump and starts them on the down grade. We next have 65 ft. of 2 per cent. grade over the automatic scale, and then 135 ft. of 3 per cent. grade, after which follows 50 ft. of 2 per cent. Then 510 ft. of 0.8 per cent., which carries over all frogs and switches of the classification or assorting yard; then 2,700 ft. of 0.2 per cent. grade, which carries into the forwarding yard. There are 21 classification tracks, with a capacity of 977 cars. Six of these tracks are extended so as to hold a full train of 80 cars each, three of the tracks being accessible from the running track, which is on the east side of the hump and paralleling the Quincy main line. These tracks are used largely for handling full trains of stock that do not have to go over the hump.

Naturally, one would think that with 21 classification tracks it would be sufficient to take care of the different separations and classification of cars for the different tracks. But when you consider that we have 52 separations or groups in the yard, that we have to keep non-air cars separated from air-brake cars going to the same destination, it will be seen that there will be more rehandling than would appear at first glance. This will be largely overcome, of course, when all cars are equipped with air, and all cars for certain destinations can be dropped onto certain tracks, instead of onto two tracks for each destination, as at present. You will readily see the necessity, then, for some rehandling, which will be largely eliminated later.

As the regularly assigned tracks for cars for certain destinations become filled, the forwarding engine, which works between the forwarding yard and the assorting yard, pushes the cars out in the forwarding yard, which is comprised at present of three forwarding tracks, holding 85 cars each.

In the organization of this hump, we have a Class D-4 engine pushing trains over the hump. The crew is comprised of an assistant yardmaster, who has charge of the entire east hump yard, foremen in charge of the hump engine, a pin puller, and ten riders. A joint tonnage and weigh clerk, located at the summit, weighs such cars as may be necessary, and keeps account of the tonnage passing into each classification track.

We have a light Class E engine, used in the classification yard for carrying the men back to the hump, which increases the efficiency of the riding force about 50 per cent. When you consider that a train of 55 cars will average about 26 cuts, with an average of about 1¾ cars to the cut, the necessity of hurrying the riders back to the hump, when doing a heavy business, will readily be recognized. The engine crew working in the forwarding yard is comprised of a foreman and two helpers.

It might be argued that the Class E engine used for carrying the riders back could be replaced by a gasoline motor. But when you figure that frequently cars with defective brakes, or bad-order cars, get into a cut, and it is necessary to let them go down the wrong track in order that they can be handled safely until the hump engine has finished handling the string of cars, the advantage of having this light engine take care of such cases can be readily seen, and the difference in cost between the light engine and the motor car is more than overcome.

This crew of men, as described, in the east hump yard, with one car-marker and a car-checker, will handle on an average of 1,050 cars each ten-hour shift.

In a recent test with a D-4 engine, we started out of the receiving yard with 95 loads and 3 empties, a total of 4,919 tons, which were handled to the summit of the hump, and the entire train shoved over without trouble.

The westbound hump is constructed on the same principle as the eastbound hump, except that we have in the incoming yard nine receiving tracks, with a total capacity of 739 cars, and four of the tracks in the classification, or assorting yard, are extended into the forwarding yard, thus giving the classification yard of the west hump a capacity of 1,196 cars direct from the hump. These four long tracks were laid for the purpose of taking care of trains of empty stock cars received from the east. Each track will hold 126 cars.

In the forwarding yard of the westbound hump we have six forwarding tracks, with a capacity of 80 cars each. In the westbound hump yard we have on the way-car and repair tracks a capacity of 138 cars, and in the eastbound hump yard for the same class of cars, a capacity for storing 115, or a total car capacity, in both yards, of 4,397 cars.

The westbound hump is operated in the same manner as the eastbound hump, except that on the night shift we have twelve riders instead of ten, as on all other shifts; this is on account of the time freight trains, which require more grouping, and necessarily faster work.

When we began using these yards, they were in an uncompleted condition, and being a new type of yard, there was much prejudice on the part of the yard force, not only the switchmen, but the yardmasters as well, to such an extent that it was necessary to import experienced hump riders to establish the practicability of handling trains over hump yards as against the old flat yard that they had been accustomed to.

Of course, the uncompleted condition of the yard had much to do with discouraging the men, and the fact that we had not yet secured lighting for the yard at nights resulted in many casualties that otherwise would not have occurred. It was not until the latter part of January, 1907, that the yard was so nearly completed as to be considered

in working condition. As a comparison I have taken the month of March, 1906, which covers the heaviest month's business ever done in the yard, with that of 1907:

Titles.	March, 1906.		March, 1907.	
	No. Men.	Wages.	No. Men.	Wages.
Yardmasters and assistants	6	$ 513.24	8	$1,021.48
Watchmen	3	116.77	2	110.00
Switch tenders	15	806.38	29	1,580.71
Switchmen	164	13,365.47	142	12,995.38
Yard office force	37	1,632.93	40	1,784.94
Total	225	$16,434.79	221	$17,492.51
Number cars handled		78,740		76,437
Enginemen	32	$ 3,455.22	24	$ 3,256.25
Firemen	32	2,107.68	24	1,723.21
Total	64	$ 5,562.90	48	$ 4,979.46
Number of engines	32	....	24	....

You will observe from this that while there was a decrease of 2,303 cars handled in March, 1907, as against March, 1906, there was an increase of $1,052 in wages paid yardmen over March, 1906. There was a decrease of eight engines per day, and a decrease in wages paid enginemen of $583, as against March, 1906.

When we consider that $483 of the wages paid enginemen, and $1,900 of the wages of yardmasters and switchmen is due to the increase in wages that went into effect November 1 and February 1, it will leave a net decrease in wages of yardmen, in 1907, as compared with 1906, of $897, and enginemen $967 for March, based on the wages paid in that month. This increase in yardmen is made up of additions to the clerical force, switchtenders, and two additional yardmasters, the additional switchtenders being made necessary on account of the spreading of the yard over so much territory.

While the actual reduction in yard operating expenses may be somewhat of a disappointment, the reduction in overtime paid to trainmen and enginemen in March, 1907, as compared with March, 1906, when trains were held out on the road for miles on either side of Galesburg, and only allowed to come into Galesburg as the yard was enabled to handle them, will overcome any disappointment that may be felt in the reduction of expenses of the actual operation of the yard. The following figures show the overtime paid trainmen and enginemen on account of Galesburg yard in March, 1907, as compared with March, 1906:

	1906.	1907.	Decrease.
Overtime	$13,253.71	$565.71	$12,688.00

The above overtime is for the Aurora, Galesburg, Beardstown and Ottumwa divisions.

Most of the $565 is chargeable to the Galesburg Division alone, caused principally by trains going out on single track, due to the inbound trains which they were to meet in the yard, and on the basis of whose arrival the outbound train was ordered, which in turn delayed work on following trains that were ordered before the delay to the inbound train became known.

This explanation is made with a view of showing the wisdom of so far as possible having double track to the first station outside of all hump yards.

Again, you must have sufficient receiving tracks to let trains in promptly and in bunches, or at least equal to the ability of the main lines that feed such receiving yards, as with the best dispatching force in the country trains will get bunched at times, by first one cause and then another, regardless of how they were separated when leaving the originating or starting point.

The general yardmaster is located at the yard office and remains there, closely handling his various assistants, which he is enabled to do by a very good telephone system.

While the new yard may not have met our expectations as to reducing the expense of actual yard operation, it has demonstrated beyond a doubt the ability to handle the traffic in transit in such an efficient and satisfactory manner as to show the wisdom of the expenditure.

The figures mentioned for March, 1906, appear a little exaggerated, as possibly a great many delays and overtime were charged to Galesburg yard in 1906 when they should not have been, although the auditor's records show the figures which I have quoted.

Appendix C.

LIST OF FREIGHT YARDS ON THE HUMP SYSTEM.

Railways and Hump Yard Locations.	Total No. of Classification Yards.	Hump Yards.	
		No. in Use.	No. Contemplated.
Baltimore & Ohio (Brunswick, Cumberland, Keeper, Fairmont, Holloway, Connellsville, New Castle Junction, Chicago)	18	8	6
Boston & Maine (Worcester)	11	1	0
Canadian Pacific (Winnipeg)	20	1	0
Central of New Jersey (Allentown, hump; Mauch Chunk, gravity, one way)	9	2	0
Chesapeake & Ohio (Russell, Ky.)	12	1	0
Chicago & Eastern Illinois (Dolton, Haney, Salem)	9	3	0
Chicago, Burlington & Quincy (Hawthorne, Galesburg)	....	2	1
Chicago, Indiana & Southern (Gibson, Ind.)	1	1	0
Chicago, Milwaukee & St. Paul (Galewood, Ill.)(poling)	3	1	0
Chicago, Rock Island & Pacific	5	0	Some
Cleveland, Cincinnati, Chicago & St. Louis (Indianapolis, Harrisburg, Mt. Carmel, Danville; contemplated at Indianapolis and Sharon)	24	4	2
Delaware & Hudson (Oneonta, N. Y.)	15	1	0
Gulf, Colorado & Santa Fe	8	0	Yes
Illinois Central (Harahan)	....	1	0
Lake Shore & Michigan Southern (Elkhart and Collinwood)	5	2	0
Michigan Central (Windsor, River Rouge, North Detroit)	11	3	Yes
Missouri, Kansas & Texas	21	0	Yes
Missouri Pacific (Part of East Yard at Kansas City operated by gravity. Yard at Dupo, Ill., contemplated)	39	1	1
Nashville, Chattanooga & St. Louis (Atlanta)	3	1	0
New York Central (West Albany, Dewitt, Avis; contemplated at Gardenville)	9	3	2
New York, Ontario & Western (Cornwall)	5	1	0
Norfolk & Western (Bluefield, W. Va.; Columbus, O., partly; Roanoke, Va., and South Norfolk, Va., to be built)	12	1	2
Peoria & Pekin Union (East Peoria)	2	1	0
Pennsylvania R. R. (Waverly, West Philadelphia, Harrisburg, Enola, Maryville, Altoona, Hollidaysburg, Pitcairn, Youngwood, Edge Moor, Honey Pot, Ebenezer)	145	12	0
Pennsylvania Lines, Southwest (Sheridan, Scully, Collier, Columbus, Bradford, Logansport, Chicago, Richmond, Cincinnati, Fulton)	18	10	0
Pennsylvania Lines, Northwest (Wellsville, Bedford, Newcomerstown, Allegheny, Conway, Mansfield, Crestline, Chicago)	46	9	0
Philadelphia & Reading	6	2	0
Pittsburg & Lake Erie (Hazleton, McKees Rocks, Glassport, Newell, Jacob's Creek, Dickerson Run)	6	6	0
Southern (Atlanta, Asheville)	....	2	0
Terminal of St. Louis (East St. Louis)	8	1	0
Union (Oak Hill, Pa.)	2	1	0
Union Pacific (assisting grade at Omaha; contemplated at Council Bluffs)	17	0	1
Wabash	20	0	Yes
Total hump yards reported to Committee	....	82	....

Appendix D.

DESCRIPTION OF INCLINED PLANES FOR HANDLING FREIGHT TRAFFIC.

A. THE ASHLEY PLANES.

(By C. H. Stein, Member of the Committee.)

The Pennsylvania Legislature on March 13, 1837, passed an act authorizing the Lehigh Coal & Navigation Co. to construct a railway to connect the North Branch Division of the Pennsylvania Canal with the slack-water navigation of the Lehigh River, and the Navigation Company accepted this act on May 10, 1837.

Edwin A. Douglas, Chief Engineer for the Navigation Company, located the route for the line of railway from White Haven to Wilkes-Barre, and it was called the Lehigh & Susquehanna Railroad. The object was to transport the coal output from the Wyoming Valley of Pennsylvania to the Atlantic seaboard. This involved what was then a marvelous piece of engineering, including a tunnel nearly a third of a mile long, and a series of inclines or planes upon which the cars laden with coal were lifted by mechanical means from the vicinity of Ashley to the summit of the mountain near Solomon's Gap, whence they were taken to White Haven by rail. There the coal was transferred to canal boats and passed on to the seaboard by way of the Lehigh Canal.

In June, 1862, floods caused the almost complete destruction of the upper division of the canal, and on March 4, 1863, the Pennsylvania State Legislature passed an act prohibiting its restoration, but in lieu thereof granted a charter for the construction of a railway from White Haven to Mauch Chunk to connect with the line from White Haven to Wilkes-Barre, previously built. March 16, 1864, a supplementary act was passed to extend the Lehigh & Susquehanna Railroad to Easton, Pa. This road was built and operated, making a direct all rail route from Wilkes-Barre to the New York harbor (by way of the Central Railroad of New Jersey).

Up to this period all freight and passenger traffic passed over the planes, but in 1866 and 1867 there was constructed what was known as the "Back Track" down the mountain side between Solomon's Gap and Ashley, over which all the passenger traffic and empty cars thereafter passed, and it is now known as part of the main line. For the handling of the heavy coal traffic, however, this would have involved a continuous climb from Ashley; 170.27 miles, from New York to Solomon's Gap; 157.8 miles, from New York, or a distance of 12.47

miles, and a total ascent of 1,013.75 ft., composed of grades 95.61, 83 and 51.4 ft. per mile, respectively, and an average grade of 81.29 ft. per mile for the distance of 12.47 miles. The use of the planes was, therefore, continued for all eastbound coal tonnage. On April 1, 1871, the Lehigh & Susquehanna Railroad was leased to the Central Railroad of New Jersey, which has since operated it.

The foot of the planes is very near to Ashley Station and the receiving yard for all the coal from the Wyoming Valley handled by the Central Railroad of New Jersey, and at the confluence of the main line of the railway and the Nanticoke Branch, tapping one of the largest anthracite coal mining districts in the world. The top of the inclines is at Solomon's Gap, the summit of the main line.

These steep inclines and level stretches at the foot resemble one another, the only variation being the difference in the length and rate of grade. The steeper the grade the shorter is the plane. The total length of the planes from point of beginning where they leave the main line to Solomon's Gap, where they tap it again, is 13,020 ft., or 2.47 miles, as against 12.47 miles by the main line, or a decrease in distance of ten miles. The lengths and gradients of the planes are as follows:

Number.	Length.	Grade.	Rise.
3	5,000 ft.	5.7 per cent.	269 ft.
2	3,000 ft.	14.65 per cent.	422.2 ft.
1	3,700 ft.	9.28 per cent.	334.7 ft.

It will be observed that this makes a rise in the aggregate of 1,025.9 ft. The short, so-called level stretches of track, however, between planes 1 and 2, and 2 and 3, descend to the extent of 5.4 and 6.75 ft., respectively, or a total of 12.15 ft., for the purpose of permitting cars when they reach the head of one plane to drift freely to the foot of the next one, thus reducing the actual ascent by the three planes to 1013.75 ft.

It must be kept clearly in mind that the object of the planes is to overcome the small tonnage movement at low speed over heavy main line grades for a distance of more than twelve miles by a rapid movement of large tonnage over a short distance of only 2.47 miles over grades largely in excess of any upon which a locomotive could operate. This is accomplished by hoisting engines of large capacity at the head of each plane, which, by means of large cables, haul the cars to the objective point. The plant naturally is not now constructed as it was formerly, but the difference is only in detail. The general principles are the same.

The loaded cars are concentrated in the receiving yard close to the foot of the planes, from where they are taken in drafts and placed over a truck pit, which will be described later, six at a time, at the foot of plane No. 3; a man at this point, called a footman, by means of a bell signals to the engineman at the head of the plane that the cars

are in position; he applies his power and a truck or "barney" which has been in the truck pit below is drawn up a set of inclined rails behind the cars. This barney is connected by a very heavy cable to the drum of the engine at the head of the plane. As soon as the engineman feels the barney go against the cars to be raised he speeds up his engine and the cars start their ascent of plane No. 3.

On each plane there are two parallel tracks, and at the foot of each one are two parallel truck pits. The cable from one truck or barney passes up the plane over sheaves about 22 ft. apart, then three times around the drums, 20 ft. in diameter, and out through the bottom of the power house over a very large sheave, which returns the cable to a barney on the parallel track. This makes a direct connection by the cable over the drums between the two barneys. Thus, when one barney ascends drawing up the cars, the barney which has been at the head of the plane descends, drops down by inclined rails into the truck pit, passes under six more loaded cars which have in the meantime been placed by the drill engine, and is now ready for its ascent. Simultaneously the first barney has reached the head of the plane with its cars, a brakeman takes charge of them, the engineman reverses his engine, the first barney starts on its descent, and the second one rises up by inclined rails out of the pit and goes behind the cars standing to receive it.

Attached to the rear of each barney is also a lighter cable, passing from the end of the one barney back to a high gallows frame from which are suspended very heavy counterbalance weights, then around a large bull wheel, returning to the other barney. The purpose of this is to equalize any slackness in the main cables of either barney.

The process is now repeated, six cars moving alternately on one track on plane No. 3, then on the other one with but slight interruption. The cars are delivered at the foot as fast as they can be drawn up the planes, or approximately so.

When the six cars have reached the top of plane No. 3 and are taken charge of by the brakeman they are cut in two parts and only three cars are handled up plane No. 2 at a time. This is accounted for by the fact that plane No. 2 has more than twice the grade of plane No. 3. It is, however, only a little more than half as long, as will be observed by reference to the data that has been given relative to each plane. The operation, therefore, is so ingeniously carried out that the six cars in two drafts over plane No. 2 are handled in the same time as the six cars in one draft over plane No. 3.

Plane No. 1 is operated similarly to No. 2, at the head of which is a 200-ton track scale, 117 ft. long, over which all the cars pass at a speed of about two miles per hour and are weighed coupled together after they have made the complete ascent of the planes. By experiment it has been demonstrated that the weights taken in this manner are practically without error. The cars may be drawn up the planes at

speeds of from 12 to 30 miles per hour. The plan and profiles of the planes are shown in Fig. 22. The information is given herewith in tabular form:

	Upper or No. 1.	Middle or No. 2.	Lower or No. 3.
Length of plane	3,700 ft.	3,000 ft.	5,000 ft.
Length of truck pits	391 ft.	397 ft.	428 ft.
Rise per 100 ft.	9.28 ft.	14.65 ft.	5.7 ft.
Total rise of each plane	334.7 ft.	422.2 ft.	269 ft.
Fall between planes	5.40 ft.	6.75 ft.	....
Distance between planes	470 ft.	850 ft.	....
Total rise, Ashley to Solomon's Gap	....	....	1013.75 ft.
Total distance, Ashley to Solomon's Gap	On Slope	....	13,020 ft.
Slope angles	5° 18′	8° 20′	3° 15′
Length of main cable	4,640 ft.	3,670 ft.	5,780 ft.
Diameter of main cable	2½ in.	2¾ in.	2½ in.
Weight per foot	10½ lbs.	11¾ lbs.	10½ lbs.
Length of tail rope	4,023 ft.	3,320 ft.	5,520 ft.
Diameter of tail rope	1½ in.	1½ in.	1½ in.
Weight per foot	3¾ lbs.	3¾ lbs.	3¾ lbs.

The chief and interesting feature of this plant is the manner in which the barney can pass down into the truck pit underneath the cars and then out of it again and up behind them. The operation would have to be seen to be best appreciated. It is accomplished by the ingeniousness of the track devices, and by the property that the wheels of the barney possess of adjusting themselves to any gage due to the axles of each wheel being independent of each other and sliding in sleeves, the one set just forward of the other, and held in place by an equalizing or lazy crank, which adjusts itself to the gage of the wheels. The construction of the barney is shown in Fig. 23. It weighs 7 tons. It will be observed that the axle of one wheel passes just to the side of the axle of its mate. Another peculiarity made necessary by the operation is that the flanges of the wheels run on the outside of the rail and are reversed to the wheels of the cars that they draw up the plane. The flanges of the wheels are 2⅛ in. deep and the treads 6 13-16 in. wide.

The novel feature in connection with the operation of this plant is the rail attachments and arrangements that make possible the drawing up of the barney against the draft of cars, its ascent to the level on the approach to the next plane, its return to its original position in the pit, making it necessary to pass under the cars already standing on the pit for the next lift. To understand the process we must always remember that the flanges of the barney wheels pass along the outside of the head of the running rails instead of along the inside; also that the journals of the wheels are movable, permitting the gage of the barney wheels to travel automatically on a wide or narrow gage. This is shown by the plan, Fig. 24.

FIG. 24.
PLAN OF RAIL ARRANGEMENT ON THE ASHLEY PLANES.

To clearly perceive the principle of the actions of the barney, we will describe its progress from the summit to the bottom of the pit, after which it is drawn up behind another draft ready to be raised. It descends along the running rail A, which is also the rail on which the traffic cars run. As it reaches the wing B the flanges spring it out, and the treads of the wheels ride on the rail C, changing their position from the track rail A, which lies on the top of the side wall of the pit to the pit rail C. At the point D there is a deflector which guides the flanges of the wheels away from the switch point, so that they might continue uninterruptedly into the pit on the rail C. (This deflector is simply a boss on a filler block which diverts the flanges of the wheels from the switch point.)

The barney has now reached the interior of the pit. It passes on down to the end (remember, the wheel flange is on the outside of the pit rail instead of on the inside, as in ordinary car wheels), springs the switch point E out and passes through. It has now reached the point where it is ready to make the ascent. The pit is about 5 ft. deep. The rail F ascends this five feet to the top of the pit wall in about 30 ft., where it parallels the main running rail A, on which the cars stand ready to be raised.

The footman signals the engineman at the top of the plane; he starts the engine, and the barney starts up the 30 ft. of inclined rail F, and goes against the cars; the engine is then gradually speeded up and the cars start up, the car wheels traveling on rail A, the barney wheels on rail F. They spring open the switch at D, the car wheels continuing on rail A, but the barney wheels being transferred to rail C, after passing point D, the car wheels are not further interrupted; but when the barney wheels reach point G they come in contact with the guard rail there, which is 3⅛ in. higher than any of the running rails. This pushes against the inside of the barney wheels, causing pressure to be exerted by the barney flange against the wing B, which opens, permitting the barney flange to pass to the outside of the head of the running rail A, whence it follows the cars up to the top of the plane, where another pit is encountered, the barney returning and a second barney following the same process over plane No. 2.

As previously stated, there are two parallel tracks on each plane, each equipped with a barney; as the first barney descends the second one rises with its draft. At the head of the plane the two tracks converge, and there is then a short stretch of single track, at the end of which two tracks again diverge. In this way the two tracks at the foot of the plane may be served with cars alternately from the tracks on the preceding plane. The rail attachments, called the rail latches, are shown in Fig. 24.

At the head of each plane are a battery of boilers and a vertical

engine which furnishes the power independently for each plane. Their horsepower rating is as follows:

	Plane No. 1.	Plane No. 2.	Plane No. 3.
Horsepower of boilers	1,500	2,000	1,500
Horsepower of engines............	1,200	1,200	1,200

The number of cars that can be conveniently handled over the three planes per hour averages 45; 60 cars may be handled with a little additional effort. The average tonnage for 24 hours has been 32,424 tons by actual demonstration. The economy of the boiler plant has been very largely increased during the past several years by the installation of a patent blower system, which resulted in a decreased cost of fuel. The planes are not constantly in operation during the entire year, nor during the entire 24 hours of a day, but to furnish some idea of the efficiency of the plant the following figures will be of some interest:

Number of days worked..................................	305
Coal tonnage hauled	4,827,104 tons
Coal tonnage and weight of car..........................	6,832,935 tons
Merchandise, tonnage hauled	974,800 tons
Coal, car and merchandise tonnage hauled in one year......	7,807,735 tons

When it is considered that one of the grades over which the cars have to be raised is 14.65 per cent. for a distance of 3,000, the suggestion forces itself upon us that the application of this principle to the operation of hump yards has much promise in it. As many cars could be handled over the hump as could be delivered by an engine from the receiving yard. The attractive feature would be that the operations on the hump would be conducted from a point where the movement of the train would be absolutely under the control of one who had clear observation of all that was going on. It would not be necessary to pass signals to the rear end of the train, with the consequent delays and troubles. The expense of operation would not be so great as in the case of a plane, on account of the speed being so much lower. There would not be the same wear and tear on machinery. The feeder engine bringing cars from the yard would have ample time to keep the truck pit supplied, hence there would be almost a continuous movement over the hump.

The indications are that cars could be classified successfully by this method, and with greater economy in cost than by any method in vogue up to this time.

B. THE MAHANOY PLANE (Philadelphia & Reading Railroad).

(By F. S. Stevens, Chairman of the Committee.)

A plan and profile of this plane are shown in Figs. 25 and 26. The cars to be lowered are dropped against the barney standing at the top of the plane. At the same time the other barney is in the pit at the

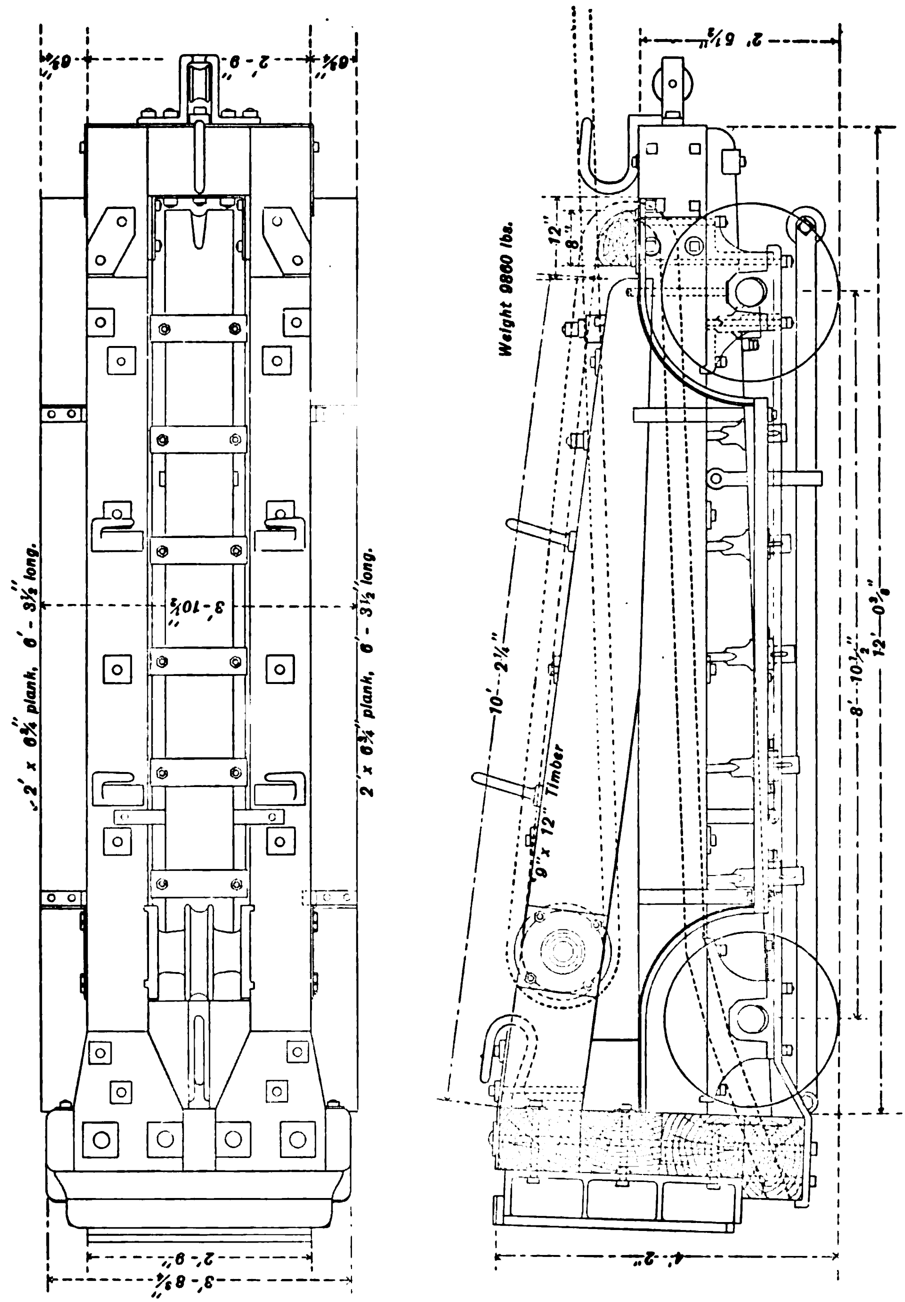


FIG. 27. CABLE PUSHER OR "BARNEY" CAR FOR MAHANOY PLANE

foot of the plane and the cars to be hoisted are pushed over it by a poling engine. The barney car is shown in Fig. 27.

The winding engine at the top of the plane is then started very slowly until the barney at the foot has risen out of the pit and has come in contact with the cars in front of it. In the meantime the cars to be lowered are over the knuckle at the top and are ready to be handled at full speed. The engines are then given speed and the cars are moved up and down at a speed about 2,500 ft. per minute until near the end of the movement, when the speed is reduced to about 1,000 ft. per minute and the barney runs into its pit at the bottom of the plane and the cars that were lowered pass over it and are caught by car riders and stopped on the tracks provided to receive them.

The cars that were hoisted are also caught by car riders and made up into trains for further movement.

A trip on the plane consumes 2½ to 3 minutes, or the plane handles 20 to 25 trips per hour. The load is 125 to 130 tons per trip hoisted and lowered 351 ft. If the winding engines are run with cars on one side only the load is 100 to 105 tons handled in the same time.

A haul of ten miles is saved by this plane. As the tonnage is practically all anthracite coal that is mined within 20 miles of the plane, and as the location of the plane is central both for assembling the loaded cars and distributing the empty cars, the advantage of gain in time by this route and method of handling must receive consideration, as well as the saving in cost of handling. On the longer locomotive route there is a single-track tunnel, about 4,000 ft. in length, operated on the train-staff system. The summit on that route is only 120 ft. lower than the summit at the head of the plane. Therefore, the conditions involve ten miles excess distance to save a lift of 120 ft. When half of this excess distance has been traveled, the advantage has been absorbed, and there are still five miles to be run with no compensation.

This feature, however, has little bearing in the case of yards and terminals, where the argument as to the economy of the short and steep plane as against the longer haul on a line operated by locomotives is not applicable.

Appendix E.

FREIGHT-HANDLING EQUIPMENT OF A BRITISH RAILWAY WAREHOUSE.

The new terminal freight station and warehouse of the North British Railway at Glasgow (Scotland) is worth attention in regard to improved facilities in American freight stations. The building is 500x 315 ft., with a basement and three main floors. On the first floor there are ten tracks, five double-side loading platforms, and three driveways 25 and 50 ft. wide. The basement and the two upper floors are used for storage. Inclined roadways enable wagons to reach the basement and the second floor. The following details are taken from an article in "The Engineer" (London), June 26, 1908:

The special feature of this warehouse is its equipment for the handling of traffic, and the unusually large electrical plant which is provided, with a view to the rapid and easy disposal of a heavy volume of goods. The tracks inside the building are arranged in sets of three, the two outside tracks of each set being used for loading purposes, while the center track is used for removing empty cars from or feeding loaded cars to the outer tracks. As no locomotives are permitted inside the warehouse, on account of fire risks, special means had to be adopted for the handling of cars. No fewer than 30 electric capstans, each capable of exerting a pull of one ton, or hauling about 100 tons on the level at a speed of 250 ft. per minute, have been laid down. Each capstan is worked by a 26 H.P. motor running at 400 revolutions per minute and driving the capstan head through a worm gear reduction.

The movement of the cars from the outer track to the center track, and vice versa, is effected by means of electric traversers running on rails laid down at right angles to the wagon rails. The cars are pulled on to the traversers by means of the electric capstans, one at a time, and traversed across to the required track, where they are then run off, the traverser thereafter being removed back out of the way. There are 11 of these machines. They are of the surface type, 12 ft. long exclusive of the ramps, and arranged to travel on three lines of rails. These traversers are capable of carrying loads of 20 tons at a speed of 100 ft. per minute, and are driven by 10 H.P. motors. There are no fewer than 15 overhead revolving cranes; 13 of 1½ tons and 2 of 3 tons capacity. All are arranged to work over the ground floor and are used for loading and discharging both cars and wagons and for general

lifting and transport purposes about the various loading platforms. All the crane runways are parallel to each other and at right angles to the railway tracks, so that whenever the necessity arises a number of cranes may be concentrated on one row of cars, insuring a rapid discharge with a minimum number of cranes. Each crane consists of a traveling gantry, 21 ft. 10 in. span, from which is suspended the balanced revolving jib having a radius of 23 ft. There are hoisting, sluicing and traveling motions, each worked by a separate electric motor at the following speeds:

3-Ton Cranes.

Lifting—3 tons at 50 ft. per minute; motor, 17½ E. H.P. at 400 revolutions.

Swinging—3 tons at 2 revolutions per minute; motor, 2¾ E. H.P. at 670 revolutions.

Traveling—3 tons at 300 ft. per minute; motor, 7½ E. H.P. at 625 revolutions.

1½-Ton Cranes.

Lifting—1½ tons at 100 ft. per minute; motor, 17½ E. H.P. at 400 revolutions.

Swinging—1½ tons at 2.3 revolutions per minute; motor, 2 E. H.P. at 800 revolutions.

Traveling—1½ tons at 360 ft. per minute; motor, 4½ E. H.P. at 650 revolutions.

The framework of the cranes, including the jib and gantry, has been constructed of steel, which gives a strong and at the same time comparatively light crane. The jib is connected to the gantry by means of a strong steel center pillar, rigidly fixed in the steel center framing on the gantry. The deadweight of the jib is carried on a large ball bearing fixed at the bottom of the pillar, whilst the horizontal thrust is taken on the rollers situated at the top of the jib framing. Machine-cut spur or bevel gearing has been used for driving each motion, and the whole of the mechanical work, including the rollers, shafts and bearings, is arranged to permit easy adjustment or renewal. Accommodation for the operator is provided immediately in front of the pillar, where he has an uninterrupted view of the operations and is within easy reach of the various controller handles. Automatic limit switches are placed on the lifting and traveling motions.

By means of a series of trap doors in the loading platforms, freight arriving by rail for storage in the basement can be readily lowered by the cranes. Freight in the basement requiring despatch by rail can be similarly dealt with.

Facilities are also provided on the upper floors for the rapid handling of goods by means of electric transporters traveling on runway girders suspended from the roof girders. The loads are lifted from the railway trucks in the loading way through wells in the floors and are

distributed by the transporters over the area of the floor covered by the respective tracks. Each track is 280 ft. long. There are four of these transporters for each floor, each capable of lifting 1½ tons. The hoisting speed under full load is 100 ft. per minute, accelerating to about double this speed for light loads, and the traveling speed is 350 ft. per minute. The height of lift for the transporters on the first floor is 34 ft. and for those on the second floor 50 ft.

Six jiggers, or short-travel transporters, also of 1½ tons capacity, are provided on the uppermost floor, which are so placed as to command the roadway on the floor below along the north side of the warehouse through trap doors in the floor, while the three remaining are placed in outside walls on the south side of the building, and may be used for raising goods from the yard to either floor, and conversely. The general design of the jigger is similar to that of the transporters, with the exception that the controllers are fixed on the warehouse floor near each track and the operator's cage is thereby dispensed with. The travel of each jigger is only 10 ft. and the height of lift is 50 ft. The hoisting speed for the full load of 1½ tons is 100 ft. per minute, and the traveling speed 200 ft. per minute.

In addition to these appliances, nine electric hoists, each of 1½ tons capacity, have also been provided (four at the west and five at the east end of the building). They are available for use on all the floors, communicating direct with the loading tables on the track floor. Two other hoists of the same capacity have been added for the use of the portion of the basement lying to the east of the building proper under the yard, and they communicate direct with two loading tables provided with special siding accommodation, apart altogether from the warehouse tables and sidings.

All these elevators are arranged to carry the maximum load at a speed of 150 ft. per minute, and they are each driven by 26 E. H.P. motors running at 400 revolutions per minute. The cages are steel framed, lined with timber, and kept in position by suitable guides fixed to the sides of the shaft.

To the south of the warehouse lies the general loading platform, capable of accommodating more than 60 cars. A considerable portion of this is roofed over, so that it forms to all intents and purposes a useful extension of the warehouse proper. Close by a 40-ton electric traveling gantry crane has been provided for dealing with heavy machinery and special loads. Small loads requiring the use of crane power are handled by means of hand cranes in the yard, the capacity of which varies from 5 tons downward.

*These traversers, of course, are for the small and light English freight cars, the capacity of the traversers being given as 20 tons.—Committee on Yards and Terminals.

DISCUSSION.

Mr. F. S. Stevens (Philadelphia & Reading):—We present for your consideration at this time a supplement to our preceding report. We have no additional conclusions to present. Our report of last year treated largely on the construction of hump yards. This year, through the courtesy of many of our members, we are able to present some facts bearing on the operation of such yards. The responses to the circulars we sent out making inquiries as to such operation indicate when analyzed that the great majority favor the placing of scales on the hump, and generally we find that the opinions expressed are that the efficiency of the yard as a classifying machine is not diminished thereby. The report, as a whole, is a report of information and we will ask that it be adopted as submitted.

Mr. W. G. Besler (Central Railroad of New Jersey):—It suggests itself to me that the report submitted by the Committee admits of very little criticism. They have submitted a most interesting and valuable report in the data which it contains, and therefore I move the action suggested by the chairman, viz., that we adopt the report.

Mr. L. C. Fritch (Illinois Central):—I. would suggest to the Committee that next year they submit to us a typical design for various classes of hump yards, yards where the majority of the cars are empty cars, and yards where heavily loaded cars are in the majority, also typical yards under various climatic conditions. I think that is something we lack.

(Motion carried.)

The President:—The Secretary suggests that the chairman of the Committee indicate some of the paragraphs which should be taken up by the members during the year, in order that the members may be prepared at the next meeting to discuss them in detail.

Mr. Stevens:—We feel that the question of construction of hump yards has been fairly well covered. We had very little, if anything, that we could present in addition to our preceding report, and as our instructions covering the work of this year were of a supplementary character, we have made what we consider a report supplemental to the report of last year, which takes up the work where our report of last year left off; that is, we constructed the yard last year, this year we have operated it and have presented the results of operation as reported to us by a considerable number of members who have had large experience in the operation of hump yards. The results of those operations you have in this report and an analysis of these indicates a very general unanimity of opinion on the principal points that we have discussed heretofore on the floor of these conventions. We do not know that we can add anything more in the light of our present information on the subject of construction. The results that have been obtained in operation are set forth at large in this report for the information of those who may be interested.

The matter of terminal warehouses is treated at some length and is illustrated for the benefit of those who may have use for such information.

The matter of transfer stations was reassigned last year, but inasmuch as at the convention of last year the members did not appear to wish to consider the suggestions that were made on points on which there were no installations to which we could refer, I will say the matter is in precisely the same condition it was left at that time, because there are still no installations of which we have knowledge to which we could refer for further light on the subject. I do not know that we can add anything or offer any suggestions on the lines of our instructions. I think we have done all we can do with the matter as it now stands.

The President:—Is it the understanding that the Committee will take into consideration the submitting of typical hump yard? If there is no objection, that will be done.

Mr. Stevens:—I might mention also in this connection that the matter of freight-handling machinery has been a live question with this Committee for several years. We have made numerous investigations, and have had a great deal of correspondence with people who have manufactured appliances of this kind and with those who thought it desirable to install them, but have not yet found anyone who has been able to recommend a telpherage system or transfer system of any kind as applicable to the transfer of miscellaneous freight. That is a live question that everybody is interested in, but nobody is able to solve. The matter of transferring goods of any kind between two fixed points is easily covered, for we can adapt our machinery to the goods we have to handle and get satisfactory results; but as soon as we attempt to apply anything that has yet been recommended to the transfer of miscellaneous freight, we are confronted with such difficult questions that we are not able to solve them and we have not found anyone who can throw any light on the subject. There is nothing that we have been able to discover except a hand truck that covers the requirements.

The President:—The Committee will be excused with the thanks of the Association.

REPORT OF COMMITTEE NO. IV.—ON RAIL.

(Bulletin 106.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee presents the following report:

COMMITTEE MEETINGS.

The following meetings of the Committee were held:

New York City, April 23, 1908—Members present: D. D. Carothers, Chairman; R. Montfort, Vice-Chairman; J. A. Atwood, A. S. Baldwin, J. B. Berry, Chas. S. Churchill, W. C. Cushing, P. H. Dudley, C. H. Ewing, J. F. Hinckley, John D. Isaacs, Howard G. Kelley, George W. Kittredge, D. W. Lum, Jos. T. Richards, J. P. Snow and Robert Trimble.

Pittsburg, May 20 and 21, 1908—Members present: D. D. Carothers, Chairman; R. Montfort, Vice-Chairman; J. A. Atwood, A. S. Baldwin, J. B. Berry, Chas. S. Churchill, P. H. Dudley, C. H. Ewing, J. F. Hinckley, Thos. H. Johnson, D. W. Lum, Jos. T. Richards, J. P. Snow, Robert Trimble and G. G. Yeomans (representing F. A. Delano).

Atlantic City, June 26 and 27, 1908—Members present: D. D. Carothers, Chairman; R. Montfort, Vice-Chairman; E. B. Ashby, J. A. Atwood, J. B. Berry, Chas. S. Churchill, W. C. Cushing, J. F. Hinckley, John D. Isaacs, Thos. H. Johnson, Howard G. Kelley, D. W. Lum, Jos. T. Richards, J. P. Snow and Robert Trimble.

Pittsburg, October 5, 1908—Members present: D. D. Carothers, Chairman; R Montfort, Vice-Chairman; E. B. Ashby, J. A. Atwood, J. B. Berry, Chas. S. Churchill, W. C. Cushing, P. H. Dudley, C. H. Ewing, John D. Isaacs, Thos. H. Johnson, Howard G. Kelley, George W. Kittredge, Jos. T. Richards, J. P. Snow, Robert Trimble and G. G. Yeomans (representing F. A. Delano).

Chicago, November 17, 1908—Sub-Committee; present: D. D. Carothers, Chairman; Chas. S. Churchill, J. B. Berry, W. C. Cushing and Robert Trimble.

BRIEF REVIEW OF PREVIOUS REPORTS.

The following summary of the contents of previous reports is given:

1900:—The preliminary report contained an historical sketch in regard to the evolution of the rail in present use; a brief discussion of rail sections in use in this and foreign countries; a discussion of the chemical constituents and mechanical treatment of rail, and length of rail. No conclusions or recommendations were given in the preliminary report (see Proceedings, Vol. 1, pp. 112-119).

1901:—The Committee suggested the use of fewer sections, the weights recommended being 60, 70, 80, 90, or 100-lb., this recommendation being based on the following information: The A. S. C. E. sections were found to be in use on about 84 railroads out of 128 reporting, as follows: Fifteen roads using 60-lb.; seven, 65-lb.; twenty-six, 70-lb.; twenty, 75-lb.; twenty-six, 80-lb.; twelve, 85-lb.; five, 90-lb., and six, 100-lb. sections.

It would appear that there are more sections provided for use than necessary. Very few roads use the 65-lb. rail, and a canvass of future needs showed that only five roads might use this weight of rail in the future.

For future requirements one road reported 56-lb.; seventeen, 60-lb.; five, 65-lb.; twenty-seven, 70-lb.; thirteen, 75-lb.; fifty-eight, 80-lb.; ten, 85-lb.; ten, 90-lb., and twelve, 100-lb.

In regard to sections other than the A. S. C. E., thirty-six weights were reported as follows: Two, 50-lb.; one, 51-lb.; two, 52-lb.; one, 54-lb.; nineteen, 56-lb.; one, 57-lb.; one, 58-lb.; twelve, 60-lb.; three, 66-lb.; one, 67-lb.; one, 69-lb.; seven, 70-lb.; two, 72-lb.; eleven, 75-lb.; one, 76-lb.; nine, 80-lb.; three, 85-lb.; one, 90-lb.; one, 95-lb., and two 100-lb.

The maximum axle loads in use for passenger engines, freight engines, and cars were collected and tabulated with the following results: No roads reported axle loads under 20,000 lbs. in use; seven roads reported axle loads from 20,000 to 25,000 lbs.; eleven, 25,000 to 30,000 lbs.; twenty-three, 30,000 to 35,000 lbs.; twenty-three, 35,000 to 40,000 lbs.; thirty-eight, 40,000 to 45,000 lbs.; fourteen, 45,000 to 50,000 lbs.; four, 50,000 to 55,000 lbs., and none over 55,000 lbs.

This report recommended the use of 33-ft. rails, which was adopted, and was accompanied by the following table giving the proper allowance for expansion to be made in laying 33-ft. rails, which was also adopted: Twenty degrees below to zero, $\frac{5}{16}$-in.; zero to 25 degrees above, $\frac{1}{4}$-in.; 25 degrees to 50 degrees, $\frac{3}{16}$-in.; 50 degrees to 75 degrees, $\frac{1}{8}$-in.; 75 degrees to 100 degrees, $\frac{1}{16}$-in.; over 100 degrees, rail to be laid close without bumping. (Temperature—Fahrenheit). (See Proceedings, Vol. 2, pp. 188-199.)

1902:—Standard Specifications for Steel Rails (Bessemer Process) were submitted and the following recommendation was adopted: "We recommend that the foregoing specification be adopted as standard for

use of members of this Association, that it be printed and distributed to the members, and that the members of the Association obtain the information suggested in regard to chemical composition and shrinkage, and submit the same for use of the Committee on Rail, from time to time, as it is secured" (see Proceedings, Vol. 3, pp. 200-206).

1903:—A verbal report of progress was presented (see Proceedings, Vol. 4, pp. 281, 282).

1904:—Some amendments to the specifications recommended which were approved.

1905:—No formal report presented.

1906:—Data was presented which had been collected by the Committee in regard to rail breakages and some comparisons between the proposed specifications of the American Society of Civil Engineers and the specifications of the American Railway Engineering and Maintenance of Way Association.

1907:—No report was presented.

1908:—Reference was made to the work of Special Committee on Standard Rail and Wheel Sections of the American Railway Association and the two series of proposed Standard Sections submitted to the American Railway Association, October 1, 1907. The Committee recommended the approval of the following cardinal principles applicable to the designing of rail sections submitted by the American Railway Association Committee in its report of October 1:

(a) There should be such a distribution of metal between the head and the base to insure the best control of temperature in the manufacture of the rail.

(b) The percentage of metal in the base of the rail should preferably be equal to or slightly greater than that in the head, and the extremities of the flanges should be sufficiently thick to permit the entire section to be rolled at low temperatures. The internal stresses and the extent of cold straightening will be reduced by this means to a minimum, and at the same time the texture of the section will be made approximately homogeneous.

(c) The sections should be so proportioned as to possess as great an amount of stiffness and strength as may be consistent with securing the best conditions of manufacture and the best service.

Your Committee recommend that the limitations as to dimension details of the sections, as given in the report of the Committee of the American Railway Association, might be approved tentatively, but not as a cardinal principle. The American Railway Association's limitations as to dimension details are as follows:

(1) The width of base to be ½-in. less than the height.

(2) The fishing angles to be not less than 13 degrees and not greater than 15 degrees.

(3) The thickness of the base to be greater than in the existing sections of corresponding weight.

(4) The thickness of the web to be no less than in the existing A. S. C. E. sections of corresponding weight.

(5) A fixed percentage of distribution of metal in head, web and base for the entire series of sections need not be adhered to, but each section in a series can be considered by itself.

(6) The radii of the under corner of the head and of top and bottom corners of base to be as small as practicable with the colder conditions of rolling.

(7) The radii of the fillets connecting the web with head and base to be as great as possible for reinforcing purposes, consistent with securing the necessary area for bearing surface under the head for the top of the splice bar.

(8) The sides of the head should be vertical or nearly so.

(9) The radii of the top corners of the head should not be less than ⅜-in. so long as the wheels continue under the present standard of the Master Car Builders' Association.

Form M.W. 2002-A (old No. 1200) for Uniform Report for Rail Failures of Main Tracks, was submitted and adopted. A discussion on rail blanks by Mr. W. C. Cushing and a paper by Mr. J. E. Howard, of the Watertown Arsenal, on the "Strength and Endurance of Steel Rails," accompanied the report.

WORK OF THE COMMITTEE IN 1908.

The Board of Direction instructed your Committee for its work during the year as follows:

(1) *Continue the investigation of the breakage and failure of rails and present summary of conclusions drawn from reports received.*

(2) *Report on the results obtained from the use of Open-Hearth Steel Rails and the chemical composition of such rails.*

(3) *Report on any recommended changes in Specifications for Bessemer Steel Rails as heretofore adopted by this Association.*

(4) *Present recommendations as to Standard Rail Sections.*

(5) *Present report showing diagrams or photographs of typical characteristic rail failures corresponding to the classification as given in old form M.W. 1200 (new form M.W. 2002-A), "Report of Rail Failures in Main Tracks."*

(6) *Joints considered as a whole. Recommend design and specifications.*

The Committee of the American Railway Association on Standard Rail and Wheel Sections in its report of March 23, 1908, recommended the following, which was adopted at the meeting held in New York, April 22, 1908:

"Your Committee respectfully recommends that the series of sections of types 'A' and 'B,' and the specifications for Bessemer and Open-Hearth Steel Rails, submitted with this report, be adopted as the recommended practice of the Association, and that the sections and specifica-

tions be referred to the American Railway Engineering and Maintenance of Way Association, with the request that they follow up the question of determining the details as to drop test, etc., by observing the actual results of rails rolled under the new sections, and that they also arrange to collect from the different members and tabulate all information as to comparative wear of rails rolled from the different parts of the ingot, and all other information necessary to a proper study of the problem. That they be further requested to keep careful record of the comparative results in service of rails of types 'A' and 'B,' and to prepare and submit to this Association a single type of section which will embody their ideas as to the best type that can be designed for use as a single standard to be adopted by this Association, giving due weight to every factor entering into the problem."

This action was conveyed to your Committee and is considered as a part of its instructions.

Your Committee, fully recognizing the great importance of the work assigned to it, has thought it wise to proceed with deliberation. At the first meeting of the Committee it was decided that on account of the large field to be covered and the size of the Committee that it would be advisable to subdivide the work, and therefore one of the essential matters for attention was the adoption of a proper organization to carry on the work. The following organization was adopted:

Sub-Committee A—Experiments and Tests:

(a) Confer with the Manufacturers' Committee, through its Chairman, from time to time, in order to keep each committee posted concerning the work of the other. It is of the greatest importance that we should lose none of the harmonious feeling which has been established by the American Railway Association between the railway men and the manufacturers.

(b) Report on best design for a drop testing machine, after conference with the Manufacturers' Committee.

(c) Report upon the results of drop tests.

(d) Recommend additional methods of testing rails.

(e) Exchange statistical information with the Committee of the Manufacturers' Association, and under instructions from the General Committee confer with kindred associations.

(f) Make such tests as may be deemed advisable by the General Committee, investigate and report upon tests made by outside parties such as the Watertown Arsenal, when available, and examine into and report upon methods of manufacture and the handling of rails at the mills.

Members: Chas. S. Churchill, *Chairman;* R. Montfort, P. H. Dudley, J. D. Isaacs, Thos. H. Johnson, J. P. Snow, F. A. Delano.

Sub-Committee B—Sections and Specifications:

(a) Recommend such changes as may be necessary in the Manual of Recommended Practice.

(b) Prepare and submit for approval a single type of rail section. It is not expected that this report can be completed until sufficient time has elapsed to complete service tests.

(c) Report upon the advisability of canting rails and the general relation of the wheel to the rail.

(d) The joint considered as a whole. Recommend design and specifications.

Members: J. B. Berry, *Chairman;* George W. Kittredge, Jos. T. Richards, J. F. Hinckley, J. W. Kendrick, Robert Trimble.

Sub-Committee C—Rail Service:

(a) Submit blanks for tabulating rail statistics.

(b) Collect and compile rail statistics. In this connection, photographs and characteristic rail failures should be collected from all parts of the country.

(c) Report on rails now in use, made of steel composed of different alloys.

(d) Make comparative statement of the results of the use of series "A" and "B" and other sections of rail.

Members: W. C. Cushing, *Chairman;* D. W. Lum, J. A. Atwood, A. S. Baldwin, Howard G. Kelley, C. H. Ewing, E. B. Ashby.

Referring to the first instruction of the Board of Direction in regard to the investigation of rail breakage and failures, your Committee has recognized the necessity of securing accurate data in order that proper deductions and conclusions may be drawn, and it considers it necessary that reports of all kinds should be on a uniform basis for reporting on the manufacture of the rail as well as its behavior afterward in the track; therefore we have devoted considerable time to the preparation and consideration of a proper scheme of blanks for reporting rail failures.

The blanks recommended were submitted to your Association for letter-ballot (see Bulletin No. 102) in order to get the blanks into use at as early a day as possible and without waiting for action at the annual meeting to be held in March, 1909.

To make this report complete, the following description of the blanks recommended is given:

Beginning with the rolling of the rail in the mill they are divided into five general groups—

GROUP I—REPORTS OF RAIL INSPECTION AND SHIPMENT AT THE MILL.

This set of forms is for the use of the railroad company's inspector at the mills where the rail is rolled, and gives all the information necessary to inform the purchaser that his order has been manufactured in accordance with the specifications and shipped.

2001—A—Report of Chemical and Physical Examination:

This blank is filled out from the mill records under the supervision

of the Inspector, and gives the chemical contents taken from the ladle analysis and the result of the drop test.

2001--B—Certificate of Inspection:

This is the Inspector's written statement that the material which he has witnessed rolled has been turned out strictly in accordance with the specifications and the order of the railroad company.

2001--C—Report of Shipment:

This blank is used for reporting the number and length of rail shipped in each car from the works and, when properly checked by the Receiving Officer, it furnishes the basis for payment of the bill.

GROUP II—REPORTS FROM DIVISION OFFICERS.

This group contains all the regular reports which come from the the division officers concerning the rails which have been put in service in track.

2002-A—Report of Rail Failures in Main Tracks:

This is the basic report of all rail failures and is sent by the Track Foreman to his Supervisor and by him transmitted to the Division Engineer. It is the form already adopted by the Association under M.W. 1200, and contains a classification of rail failures which is used in the tabulations employed in the following blanks.

2002-B—Superintendent's Monthly Report of Rail Failures in Main Tracks:

On this blank the Division Engineer informs his Superintendent of the total number of rail failures for the month tabulated from the Track Foreman's report, and other officers who are interested, such as the Chief Engineer, Chief Engineer of Maintenance of Way or General Superintendent, are furnished with copies. In cases where a copy of the Track Foreman's Report is sent to the Chief Engineer or Chief Engineer of Maintenance of Way, the monthly report serves as a check on the receipt of all individual rail reports.

2002-C—Annual Statement of Steel Rails Existing in Main Tracks:

This is an annual report sent by the Division Engineer to the Chief Engineer or Chief Engineer of Maintenance of Way for the permanent record of the Company, to show the different kinds of steel in the main tracks at the end of the year. This may be used in conjunction with the rail chart, or take its place altogether, because the rail chart is not in convenient form for a permanent record which may be referred to, after many years, for information concerning the kind of rail in use at a stated period.

GROUP III—LABORATORY EXAMINATION OF SPECIAL RAILS.

2003-A:

This group is, at present, represented by this single form. It is used for making check analyses against the mill analyses and for re-

porting the result of chemical analysis and physical test of special rail or other test pieces which may be sent to the laboratory, from time to time, for examination.

GROUP IV—COMPILATION OF RESULTS FOR STUDY.

This group exhibits the different ways for compiling quantitative statistics of rail failures.

2004-A—Summary of Steel Rail Failures for Six Months Compared with the Same Period of Previous Year:

This blank is intended for compiling the information relative to rail failures for a period of six months. It can also be used for other periods if found desirable. The failures are reduced to percentage of tons of rails laid in preference to the number of rail per thousand tons of rail laid, for the reason that the latter does not take care of different lengths of rail, which the former does.

The columns for "specified chemical analysis" are intended for recording the analyses of the particular lot of rail as given in the specification, and is inserted in this blank in order to give an idea as to whether the rail is high or low in carbon, or high or low in phosphorus, etc.

2004-B—Summary of Steel Rail Failures for a Period of Years:

The railroad company is supposed to be keeping a continuous record of rail failures, and it is desirable to have the record reach as far back as possible; therefore, this blank has been provided on which the results from 2004-A will be recorded at the end of the year, thus making a continuous record.

2004-C—Comparative Number of Failures of Steel Rails of Different Section or Pattern, Rolled by Different Steel Companies:

In order to compare, at a glance, the product of different mills, and also to compare different weights per yard and different sections together, this blank has been provided. It contains the totals taken from 2004-A or 2004-B, as desired.

2004-D—Position in Ingot of Steel Rails Which Failed:

This is intended to furnish data on the number and character of rail failures according to the original position in the ingot held by the rail in question.

2004-E:

The information in this group should be bound together in one book; this cover has been provided for convenience and neatness.

GROUP V—PROGRESSIVE WEAR OF SPECIAL RAIL UNDER OBSERVATION.

In order to keep track of special rail, from time to time, and determine the value of the results being given, it is necessary to have a systematic plan of procedure for examinations and records. This

group is furnished for that purpose, and is provided with a cover, as in the case of the previous group.

2005-A—Location Diagram:

This blank is on a scale one in. equals one mile, and is intended for diagrams showing the location in different places of the same kind of rail under trial.

2005-B—Location Diagram:

This is the same as 2005-A, except that it is on a scale of two in. equals one mile, and is intended to show the location of a particular portion of the rail given in 2005-A. It is made on a larger scale, so as to locate the points of measurement. A place is provided on each blank for the summary of the wear or area abraded in percentage of total area of head.

2005-C—Diagram Showing Lines of Wear:

The measurement of rail section at a specified point is shown on this blank and its position on 2005-B is given by the number in the circle in the center of the blank at the top. All statistical information of interest and importance is given on the blank.

2005-D—Record of Comparative Wear of Special Rail:

This blank is intended for compiling the information given in the previous ones, so as to give a general summary of the results.

REPORTS REQUIRED BY THE RAIL COMMITTEE.

Your Committee understands that the main part of its work, in this connection, is to study rail failures quantitatively, and the blanks have been drawn up with that end in view. A quantitative tabulation of rail failures, from year to year, ought, ultimately, to give valuable information to the Association by serving as an index, by numbers, whether the results obtained from the new patterns of rail rolled under the specifications are coming up to the expectations. The way has already been paved for such information by the classification of rail failures on the back of the Track Foreman's report blank, M. W. 2002-A, which was adopted by the Association at the last annual meeting in March.

Although the Rail Committee recommends the above series of blanks to the members of the Association as suitable for keeping rail service records, it will itself only need three for receiving the quantitative reports of failures from the members.

These three forms, 2004-A, 2004-D and 2005-D, will be supplied and sent out to the members by the Committee to be filled out for the six months' period ending October 31, and similar information will thereafter be regularly requested for six months' periods, viz.: April 30 and October 31, this division of periods being intended to give winter and summer periods, in order to study the effect of each.

Your Committee feels that the study of individual rails can only

be taken up in part, as it is impossible for the Committee to consider the individual rail failures on all the railroads in our membership. It is, therefore, assumed that each member of the Association will make the study of individual rails for his own system, digest the information as much as possible, and furnish the Committee with accurate information which may be of value to all the members and enable them to draw proper conclusions.

The following resolutions were submitted to the Association for letter-ballot:

"Resolved, That the complete set of rail statistic blanks previously described be used by the members of the Association for reporting and compiling information relative to rail failures and rail service.

"Resolved, That form 2004-A, Summary of Steel Rail Failures for Six Months, Compared with the Same Period of Previous Year; form 2004-D, Position in Ingot of Steel Rails Which Failed, and form 2005-D, Record of Comparative Wear of Special Rail, be adopted by the Association as approved forms for receiving statistics for the quantitative study of rail failures.

"Resolved, That the members of the Association furnish the Rail Committee with reports of studies of individual rail failures or rail service, from time to time, as soon as such studies have been made.

"Resolved, That these recommendations be accepted and put into effect at once by the members of the Association, subject to revision at the annual meeting."

The result of the ballot to November 5, 1908, was as follows:

For Rail Record Blanks	261
Against	10
Blank	6
Total	277

Your Committee recommends that the blanks described above and approved by your Association by letter-ballot be added to the Manual of Recommended Practice.

The Committee has arranged to have forms 2004-A, 2004-D and 2005-D, for report of rail failures for six months ending October 31, 1908, sent to the railroads of the country through the American Railway Association.

The quantitative statistics will show whether rail failures are increasing or decreasing, from year to year, and what particular kinds of failures are the most numerous, but it will be necessary also to have the information to be derived from the study of individual rails in order to determine, as nearly as possible, the cause or causes for the different kinds of failures so that we may apply our knowledge to the correction of the troubles.

The following plan is, therefore, suggested for each official charged

with the study of rail failures for use both for his own benefit and for the benefit of the Rail Committee:

(1) Four rails of every hundred which have failed in service should be selected for investigation and analysis.

(2) As the Track Foreman's reports on form M. W. 2002-A come from the Division Officers, the Chief Engineer, or Chief Engineer of Maintenance of Way, should select four cases out of every hundred which, in his judgment, will furnish valuable information upon being investigated. If he desires he may leave this selection to the Division Officer, as it may happen that the Division Officer may have a better opportunity for selecting good samples than his superior. As soon as the selections have been made blank M.W. 2002-A, for the special rail in question, should be checked by an engineer by a visit to the place where the rail was found, and he should also inspect the rail.

(3) The selected rail or piece of it should be sent forward to the laboratory where it is to be examined and a copy of the checked Track Foreman's report, M.W. 2002-A, should be sent to the laboratory, and the Chief Engineer or Chief Engineer of Maintenance of Way should also retain a checked copy.

(4) At the laboratory there should be made:

(a) Photographs of the defective or broken rails.

(b) A chemical analysis.

(c) A physical test, such as tensile strength, elastic limit, elongation, etc.

(d) Photo-micrographs showing the structure of the material.

The chemical and physical results should be reported to the Chief Engineer or Chief Engineer of Maintenance of Way on form M. W. 2003-A, and the photographs and micro-photographs, made on the same size sheet, should be pinned to it. If the place for remarks on the form is not sufficient to explain the results of the examination, further explanation can be given in a letter.

Upon receipt of this report, the Chief Engineer or Chief Engineer of Maintenance of Way can, if desirable, add the chemical analysis originally obtained from the mill, and also the drop test. The complete report would then consist of:

(a) Copy of the Track Foreman's report on form M. W. 2002-A, after being checked by an engineer.

(b) Results of chemical analysis and physical test on form M. W. 2003-A.

(c) Photographs of the defect or fracture and micro-photographs of the interior structure.

(d) A complete written analysis or deduction from the study of the above information.

The Rail Committee should receive a copy of such a study or else a report by the Chief Engineer or Chief Engineer of Maintenance of Way, giving the results of a collection of similar studies.

A. B. & C. R. R. Co.

Report of Chemical and Physical Examination

Sheet No._____
of_____Sheets

of________ Rails ____________________ Process_________ lbs. per yd._______ Section
No. (Open Hearth, Bessemer or Special)

Manufactured by__________________Steel Co., at ______________________Works

For ____

Order No. ________ Date of Report _________________19____

No. of Passes in Rolls__________ Bar held on average of_______seconds at_________Pass.

Shrinkage Allowance at Saws_____________inches on 33-ft. rails

Distance between supports on Straightening Press___________________

Weight of Tup, 2000 lbs. Height of Drop _________ft Distance between Supports, 3 ft

Average Number of Rails per Heat ____

Heat No.	Percentage of Crop from Ingot.			Carbon.	Manganese.	Phosphorus.	Silicon.	Sulphur			Drop Test Deflection Inches.	Remarks	
	No. of Ingots	% from Top	% from Bottom										
													1
													2
													3
													4
													5
													6
													7
													8
													9
													10
For	filling in	with ty	pewriter	columns	should	be spa	ced in te	nths of	an inch	as given	by the fi	gures	11
7	4	5	5	5	5	5	5	5	5	5	5	11	12
				Size of	sheet re	quired,	8x10½ in	ches.					13
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													30
													31
													32

Note—Requirements of Standard Specifications are to be stated on line 1

Instructions

One copy of this report to be forwarded to the Chief Engineer M of W

Correct __________________________
Inspector

Approved __________________________
Chief Inspector
Engineer of Tests

Form M. W. 2001-B.

A. B. & C. R. R. Co.

No.________

CERTIFICATE OF INSPECTION

of ____________ Process Rails__________lbs. per yd.________________Section.
(Open Hearth, Bessemer or Special)

Manufactured by________________________Steel Co. at__________________Works

For____

Mr.______________________Chief Engineer M. of W. Date_______________19___

The following Steel Rails have been inspected and accepted according to contract.

Rails are certified to be within the limits of the Specifications of the____________________

____

and approved as per details given below.

All Rails have been inspected and approved for Chemical Analysis, Physical Tests, Section, Weight, Straightening, Drilling, Sawing, Length, Stamping, Finish, Quality.

All Rails are marked on the web with maker's name, date of manufacture, Heat Number, and position occupied in the ingot. Date of Rolling____________________

No. of Rails Rolled _______________ No. of Rails Accepted _______________

No. of Rails temporarily rejected and cause ______________________________

____

____

No. of Rails condemned and cause ______________________________

____

____

For filling in with typewriter columns should be spaced in tenths of inch as shown by the figures under columns. Size of sheet required, 8 x 10½ inches.

This Certificate covers the run from

Heat No.__________ to Heat No.__________both inclusive

Number of Rails of each Length.

Length		33	30		27½		25		Total.
Number									
7	6	6	5		4	4	4	4	6

Calculated Weight.			Shipper's Scale Weight		
Total Pounds	Tons	Pounds	Total Pounds	Tons	Pounds
11	7	7	11	7	7

Trial Weights

Hours	Wts	Hours	Wts
6 A		6 P	
7 "		7 "	
8 "		8 "	
9 "		9 "	
10 "		10 "	
11 "		11 "	
12 M		12 M	
1 P		1 A	
2 "		2 "	
3		3 "	
4 "		4 "	
5 "		5 "	
5	6	5	6

Amount accepted under this Certificate____________________

Total amount of Order ______________________

Balance due on Order ______________________

Instructions

One copy of this Certificate is to be made out and forwarded to the Chief Engineer M. of W. of the Railway Company

Correct.____________________________
Inspector.

Approved ____________________________
Chief Inspector Engineer of Tests.

Form M. W. 2001-C.

Copy Ink.

A. B. & C. R. R. Co.

No._____

REPORT OF SHIPMENT.

of _________________ Process Rails __________lbs. per yd ___________Section
(Open Hearth, Bessemer or Special)

Manufactured by _____________________Steel Co. at _________________Works.

for ____

Consigned to ____

Order No. _______________ Date of Report ____________________19__

Quality No. ______________ Sheet No _____of____Sheets.

	Loaded on Cars.		Number of Rails of each Length.									Shipper's Weights,
	Initial	No.		33	30		27½		25		Total Rails	Pounds
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14	For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures.											
8 15	9	9	5	5	5	5	5	5	5	5	6	8
16				Size of sheet required 8x10½ inches								
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
32												
		Totals.										
	Total Weight Expressed in Gross Tons and Decimals.											

Total Tons of Order ______ Tons previously shipped _____ Balance due __________

INSTRUCTIONS

One copy of this report is to be sent to the Chief Engineer M of W., and two copies to the General Superintendent, one of which is for the Division Superintendent.

Correct ___________________________
Inspector

Approved ___________________________
Chief Inspector
Engineer of Tests

A. B. & C. R. R. Co.

____________________ Division

REPORT OF RAIL FAILURES IN MAIN TRACKS.

Section No. ________ Date of Report ______________ 19__

1.	Weight per yard, New__lbs; Re-rolled__lbs.	16.	By whom discovered? ______________
2.	Rail Section ____________________	17.	Date and Time found ______________
3.	Brand on Rail ____________________	18.	Was Rail removed? ______________
4.	Heat No. on Rail ____________________	19.	If removed give date ______________
5.	Rail No. or Letter. (See Note "D" on back)_	20.	Exact gage of track at break __________
6.	Original Length of Rail ______________	21.	Was break over or between ties? ________
7.	Month and Year Rail was Laid __________	22.	Was break square or angular? __________
8.	Location ______ ft. ______ of Mile Post__	23.	Distance between edges of ties at break ____
9.	Which Track? ______ Which Rail? ______	24.	Condition of ties each side of break ______
10.	On Curve or Straight Line? ___________	25.	Kind of ties ______________________
10½.	No. of Curve ____________________	26.	Were tie plates used? _____ Kind ______
11.	Degree of Curve __________________	27.	Condition of Line and Surface ________
12.	High or Low Rail, if on Curve _________	28.	Kind of Ballast ____________________
13.	Superelevation of Curve at break _______	29.	Was Track properly ballasted? _________
14A.	Was Rail broken? _________________	30.	Kind of material in roadbed under Ballast ______________________
14B.	Was Rail damaged? ________________		
14C.	Was Rail defective? _______________	31.	Was track well drained? ____________
15.	Was Rail much or little worn? _________	32.	Was roadbed frozen? ______________

33. Condition of weather, (wet, dry, warm or cold freezing or thawing) __________________

34A. If break was at Joint, state kind, number of holes, and whether it was full bolted or insulated
____

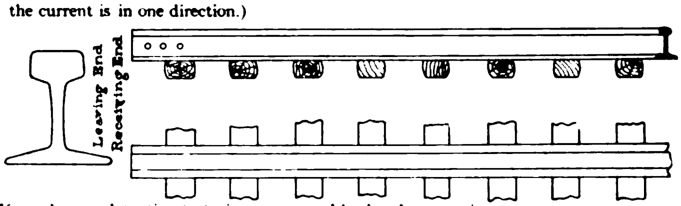
34B. Were any bolts at joint loose? ______ If so, how many? ______________________

35. If broken, state cause of break and describe any flaws found at point of break ____________
____

36. If damaged, describe nature and cause, if known. (See instructions on back.) ____________

37. If defective, describe location of flaws or defects, and if possible what caused them. (See back of report for description of failures.) ____
____
____

38. Draw on Diagram lines of break or partial fracture, such as long pieces from side of head and half moon pieces from base, showing dimensions. Hollows in head should be shown on end section. Defects may also be indicated on diagram. Mark distance from end to break. *If break is nearest "Receiving End," draw pen through words "Leaving End." If nearest "Leaving End" draw pen through words "Receiving End." (*Refers to track upon which the current is in one direction.)



39. If accident or detention to trains was caused by break, state circumstances ____________
____

Correct: Approved:

__________________ (*) ___ __________________ (*) _______

*Each railroad will fill in these blanks to suit its practice.

Back of Form M. W. 2002-A.

INSTRUCTIONS.

The (_____*_____) will send this report to the (_____*_____) the same day the break is discovered and in the case of a damaged or defective rail, the day it is taken out of the track.

The (_____*_____) will forward this report direct to the (_____*_____).

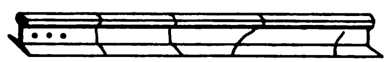
The (_____*_____) will have copies of this report made immediately upon receipt and send copy to each of the following officers (_____*_____) and (_____*_____).

The Rail Number or letter in 5 (front page) will be found a few inches to the right of the Heat Number and is marked with a letter of the alphabet or number.

DESCRIPTION OF RAIL FAILURES.

When describing Failures of Rails, the following terms should be used:

1. **Broken Rail.** This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

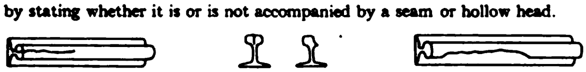


2. **Damaged.** Under this head will be included all rails broken or injured by wrecks, broken wheels, or similar causes.

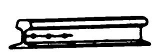
3. **Flow of Metal.** This term means a "Rolling out" of the metal on top of the head toward its sides without there being any indication of a breaking down of the head structure; that is, the underside of the head is not distorted.

4. **Crushed Head.** This term is used to indicate a "Flattening" of the head, and is usually accompanied by a crushing down of the head as shown in sketch.

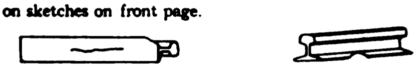
5. **Split Head.** This term includes rails split through or near the center line of the head or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.



6. **Split Web.** This term is a longitudinal split along the axis of the web generally starting from the end of rail through the bolt holes.



7. **Broken Base.** This term covers all breaks in base of rail and should be described and illustrated on sketches on front page.



*Each railroad will fill in these blanks to suit its practice.

Form M. W. 2002-B.

A. B. & C. R. R. Co.

_____________ Division _____________ Branch

Superintendent's Report of Rail Failures in Main Tracks for the Month of __________ 19___

Sheets No. _______ of _______ Sheets.

Description of Rail.							Location of Rail.										Nature of Failure.										
		Marks on Rail					Mile Post																			
Weight per Yard	Type of Section	Manufacturer	Date Rolled	Heat No	Rail No.	Length	No	*Feet.	Which Track.	Curve or Tangent.	Degree of Curve.	Super-elevation.	Date Laid.	Day of Month Found.	Time in Service when found.	Damaged.	Broken.	Flow of Metal.	Crushed Head.	Split Head.	Split Web.	Broken Base.	Removed or Spliced.	In Splice.	Out of Splice.	State cause of Rail Failure when known, and remark on defects in Cols. 17 to 23 incl.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
																										1
																										2
																										3
																										4
																										5
																										6
																										7
																										8
																										9
																										10
																										11
																										12
																										13
																										14
																										15
																										16
																										17
																										18
																										19
														Total Failures →												
																										← Grand Total of Failures for Month.

INSTRUCTIONS.

Use following Marks for making entries in Columns:
In Col. 10, use E. B. P. for East Bound Passenger, etc.
" " 11, use T for Tangent, I. C. for Inner Rail on Curve; O. C. for Outer Rail on Curve.
" " 17, 18, 19, 20, 21, 22, 23, use Fig. "1" to designate proper column.
" " 24 use R for Removed, and S for Spliced.
" " 25, use "I."
" " 26, use "O"
Grand total of Cols. 25 and 26 should equal grand total of Cols. 17 to 23 inclusive.

Correct:

____
Engineer M. of W

Approved:

____
Superintendent

M. W. 2002-B.

INSTRUCTIONS.

A. The Engineer of M. of W. will make out two copies of this report at the end of the month from the Section Foreman's reports, and send one copy to the Chief Engineer M. of W. and one to the General Superintendent.

B. Mile Post Number from $\left\{ \begin{matrix} \text{South} \\ \text{East} \end{matrix} \right.$ end of Division to be used.

DESCRIPTION OF RAIL FAILURES.

When describing Failures of Rails, the following terms should be used:

1. **Broken Rail.** This term is to be confined to a rail which is broken through, separating it into two or more parts. A crack which might result in a complete break will come under this head.

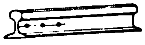
2. **Damaged.** Under this head will be included all rails broken or injured by wrecks, broken wheels or similar causes.

3. **Flow of Metal.** This term means a "Rolling out" on top of the head towards its sides without there being any indication of a breaking down of the head structure; that is, the underside of the head is not distorted.

4. **Crushed Head.** This term is used to indicate a "Flattening" of the head and is usually accompanied by a crushing down of the head as shown in the sketch.

5. **Split Head.** This term includes rails split through or near the center line of the head or rails with pieces split off the side of the head. When this term is used it should be further defined by stating whether it is or is not accompanied by a seam or hollow head.

6. **Split Web.** This term means a longitudinal split along the axis of the web generally starting from the end of rail through the bolt holes.



7. **Broken Base.** This term covers all breaks in base of rail.

Form M. W. 2002-C.

A. B. & C. R. R. Co.

______________________________ Division.

Statement of Steel Rails existing in Main Tracks of ______________________________ Division.

_______________ Main Track. December 31, 19___

Location.				Year Laid.	Brand.	Weight per Yard.	Type of Section.	Length of Feet in Track			
From		To						Laid Previous to 19	New Steel Laid 19	Steel Laid 19	Remarks.
M.P.	+ft.	M.P.	+ft.					1	2	3	4

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures

4	5	4	5	3	12	4	5	8	7	7	16

Size of sheet required 8 inches wide.

No. ft. 60 lb. Rail No. Tons
" " 70 " " " "
" " 85 " " " "
" " 100 " " " "

Column 3 to be used for any special rail, such as Re-rolled or Sawed and Re-drilled.

To be made out and forwarded by the Engineer M. of W. to the Chief Engineer M. of W., as soon after the close of the year as possible.

Correct:

Engineer M of W

Form M. W. 2003-A.

Copy Ink.
Report No.

A. B. & C. R. R. Co.

Laboratory Report of Chemical and Physical Examination of Rail and Other Track Material.

Referred to in____

Laboratory No.__________ Sample represents ________________________________

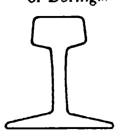
Place and Date ________________________ 19___

	Chemical Analysis.										Physical Test.							
Location of Borings	C.	P.	Mn.	Si.	S.		-				Tensile Strength	Elastic Limit	Elong. % in___ in.					
11	5	5	5	5	5	5	5	5	5	5	7	1	6	6	6	6	6	

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures:

Size of sheet required, 8x10½ inches.

Location of Borings.



Remarks.

Approved:

____
Chemist
Engineer of Tests.

Note: The word "Borings" refers also to "Chippings" and other kinds of test fragments.

Form M. W. [illegible]-E

A. B. & C. R. R. CO.

______________________________ Division

Numerical Record and Position in the Ingot of Steel Rails which have Failed in Service.

On ______________________________

Year ________ to Year 19______

Office of CHIEF ENGINEER M. of W.
(or other officer)

Form M. W. 2004-A.

A. B. & C. R. R. Co.

____________________ Division

____________________ Branch

Summary of Steel Rail Failures for 6 mos. compared with same period of previous year.

___ lbs. ______ Sec. ______________ Steel. Rolled by ______________________ Steel Co. ___ Record for Period of ________________ ending ________ 19 ___

Year Laid	Tons of New Rail Laid	Specified Chemical Analysis C.	P.	Mn.	Si.	S.		Maximum Axle Load of Locomotives Freight	Passenger	Approx. Gross Tons over Rail	No. of Rails which failed From ______ To ______ Tan.	Curve		Kind of Failure: Broken Tan.	Curve	Flow of Metal Tan.	Curve	Crushed Head Tan.	Curve	Split Head Tan.	Curve	Split Web Tan.	Curve	Broken Base Tan.	Curve	Aggregate Length and Width of Rails which Failed: Total Length in Feet	Total Weight in Tons	Failures in Percentage of Tons of Rail Laid Year ___	Year ___
189													% No.																
189													% No.																
189													% No.																
													% No.																
													% No.																
		For filling in with typewriter columns should be spaced in											% No.																
		tenths of an inch as given by the figures:											% No.																
5	6	5	5	5	5	5	5	8	8	6	5	5	4 No.	4	4	4	4	4	4	4	4	4	4	4	4	7	7	5	5
		Size of sheet required, 8 x 15½ inches.											% No.																
													% No.																
													% No.																
													% No.																
													% No.																
													% No.																
													% No.																
													% No.																
													% No.																
													% No.																
													% No.																
Totals																													

9

Note: Only statistics of Rails weighing over 70 lbs. per yard are required.
Rails broken or injured by wrecks, broken wheels or similar causes, are not to be included in this report.
The 6 months periods are to extend from April 30 to Oct. 31., and from Oct. 31 to April 30.

Form M. W. 2004-B.

A. B. & C. R. R. Co.

________________ Division.

Summary of Steel Rail Failures for a Period of Years.

______ lb ________ Section __________ Steel. Rolled by ____________________ Steel Co. Record for Period of __________ ending __________ 19__

Year Laid	Tons of New Rail Laid	Number of Rails which have failed each year below.											Total			Kind of Failure												Aggregate Tonnage of Rails which Failed	Failures in Percentage of Tons Laid
																Broken		Flow of Metal		Crushed Head		Split Head		Split Web		Broken Base			
		189	189										Tan	Curve		Tan	Curve	Tan	Curve	Tau	Curve	Tan	Curve	Tan	Curve	Tan	Curve		
189															No.														
189															No.														
															No.														
															No.														
															No.														
															No.														
5	7	5	5	5	5	5	5	5	5	5	5	5	5	5	No.	5	5	5	5	5	5	5	5	5	5	5	5	7	5
														2	No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
															No.														
Total																													

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures.

Size of sheet required, 8 x $15\frac{8}{10}$ inches.

Note: Rails broken or injured by wrecks, broken wheels or similar causes, are not to be included in this report.

A. B. & C. R. R. Co.

Sheet No.________ of________ Sheets.

________________________________Division

Comparative Number Of Failures of Steel Rails of Different Section or Pattern Rolled by Different Steel Companies.

Record for Period of____________________ending________________19____

	Steel Company and Mill where Rail was Rolled	Rail weight per yard, lbs.	Rail Section or Pattern	No of Tons of Rail laid in Track	Kind of Failure														Aggregate Tonnage of Rails which Failed	Failures in percentage of Tons Laid.
					Broken		Flow of Metal		Crushed Head		Split Head		Split Web.		Broken Base		Total			
					Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve	Tan.	Curve		
	Steel Co.																			
	Mill																			
7	10	4	5	7	4	4	4	4	5	4	5	4	4	4	4	4	5	5	7	5

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures:

Size of sheet required, 8x10½ inches.

Note: The percentages which the record figures are of the total are to be put above the record figures in the several columns under "Kind of Failures."

Form M. W. 2004-D.

A. B. & C. R. R. Co.

-------------------------------------Division

Position in Ingot of Steel Rails which Failed for Period of____________ending________19___

Sheet No.______ of_______Sheets

____________________Type of Rail Section

Kind of Failure	Mill																Mill															
	100 lb.								85 lb.								100 lb.								85 lb.							
	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total	A	B	C	D	E	F	Unknown	Total
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Mill																Mill															
Broken																																
Flow of Metal																																
Crushed Head																																
Split Head																																
Split Web																																
Broken Base																																
Totals																																
	Mill																Mill															
Broken																																
Flow of Metal																																
Crushed Head	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5	4	4	4	4	4	4	5	5
Split Head																																
Split Web																																
Broken Base																																
Totals																																

For filling in with typewriter columns should be spaced in tenths of an inch as given by the figures:

Size of sheet required, 8x15$\frac{8}{10}$ inches.

Note: The letters A, B, C, etc., denote the position of the Rail in the ingot, "A" being the top rail, "B" the second, etc.
The percentages which the record figures are of the total are to be put above the record figures in the columns under A, B, C, etc.,
Only Statistics of Rail weighing over 70 lbs. per yard are required.

Form M. W. 2005-E

A. B. & C. R. R. CO.

______________________________Division

RAIL SECTIONS

Showing Progressive Wear
of

______________________and______________________Steel Rails.

Laid______________________ Removed______________________

Office of CHIEF ENGINEER M. of W.
(or other officer)

Form M. W. 2005-A.

A ____________ shown in Red   B ____________ shown in Yellow

Summary

Month and Year												
Kind of Rail	A	B	A	B	A	B	A	B	A	B	A	B
Total sq. in. abraded												
Ave. sq. in. abraded per Section												
Percentage of Area abraded to total Area of Head												

A. B. & C. R. R. Co.

____________________________ Division

Location Diagram

of

____________________________________ Rails

Laid in 19 ____________ Removed in 19 ________

Between ________________ and ____________________

Office of Chief Engineer M. of W. ______________ R. R.

Scale 1 in.=1 mile   Date ____________________

Form M. W. 2005-B.

A ____________ shown in Red B ____________ shown in Yellow

Summary

Month and Year												
Kind of Rail	A	B	A	B	A	B	A	B	A	B	A	B
Total sq in abraded												
Ave sq in. abraded per Section												
Percentage of Area abraded to total Area of Head												

A. B. & C. R. R. Co.

____________________________ Division

Location Diagram

of

__________________________________ Rails

Laid in 19 ____________ Removed in 19 ______________

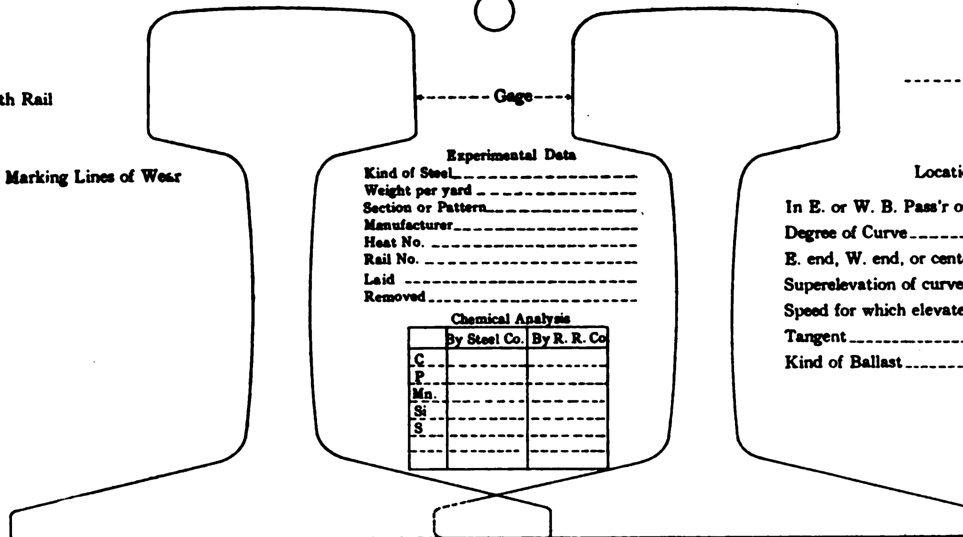
Between ______________ and ____________________

Office of Chief Engineer M. of W. ____________ R. R.

Scale 2 in. = 1 mile Date ____________________

Form M. W. 2005-C.

No. showing Location in Track



Low or South Rail

Scheme of Marking Lines of Wear

Gage

High or North Rail

Experimental Data

Kind of Steel
Weight per yard
Section or Pattern
Manufacturer
Heat No.
Rail No.
Laid
Removed

Chemical Analysis

	By Steel Co.	By R. R. Co
C		
P		
Mn.		
Si		
S		

Location Data

In E. or W. B. Pass'r or Frt.
Degree of Curve
E. end, W. end, or center of curve
Superelevation of curve
Speed for which elevated
Tangent
Kind of Ballast

Measurements taken at Rail Center

Measurements of Area Abraded

Date of Measurement	Sq. in. Abraded: Low Rail, Area Abraded	Low Rail, Diff.	High Rail, Area Abraded	High Rail, Diff.

Div.
Diagram Showing Lines of Wear
of
Rail
Laid in 19 Removed in 19
Between and
Office of Chief Engineer M. of W. R. R.
Scale, Full Size. Date

Form M. W. 2005-D.

A. B. & C. R. R. Co.

.... Division

Record of Comparative Wear of Special Rail

Date of Report .... 19.....

Special Rail													Chemical Composition of Rail of Section with which Special Rail was Compared							Special and Comparative Rails						
Kind of Steel	Location	No. of Tons Laid	Weight per yard	Type of Section	Manufacturer	Chemical Composition														Date Laid	Date Removed	Length of Service at date of Report	Average Area Abraded of all the Sections taken			
																							Special		Comparative	
						C	P	Mn	Si	S			C	P	Mn	Si	S						Sq. in. abraded	% of area of Head	Sq. in abraded	% of area of Head
12	14	6	5	6	10	4	4	5	4	4	4	4	4	4	5	4	4	4	4	6	6	6	5	5	5	5

For filling in with typewriter columns should be spaced in tenths of an inch as shown by the figures:

Size of sheet required, 8x15 $\frac{8}{10}$ inches.

Note: Only Statistics of Rails weighing over 70 lbs. per yard are required.

PENNSYLVANIA LINES WEST OF PITTSBURGH.
SOUTH WEST SYSTEM.
Summary of Steel Rail Failures.

100 lb. A.S.C.E. Section.—Rolled by Carnegie Steel Co.—Record for Period ending Dec. 31, '07.

Year Laid	Tons of New Rail Laid	Number of Rails which have failed each year below: 1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	Total	Kind of Failures: Broken	Flow of Metal	Crushed Head	Split Head	Split Web	Broken Base	Aggregate Length and Weight of Rail which Failed: Total Length in Feet	Total Weight in Tons	Percentage of Tons Laid
1902	1770							0	2	3	7	1	3	16	4		4	8			528	7.9	0.4
1903	52																						
1904	7																						
1905	57																						
1906	6415											6	75	81	10	3	28	29	7	4	2648	39.4	0.6
1907	9003												17	17	3		11	2		1	561	8.3	0.1
Total	17304							0	2	3	7	7	95	114	17	3	43	39	7	5	3737	55.6	0.32
		85 lb. P.R.R. Section. Rolled by Carnegie Steel Co.																					
1895	5087	5	4	1	18	1	2	1		3	1	1	9	46	3		31	12			1379	17.4	0.3
1896	6102	4	4	6	7	13	1	6	6		1		1	49	7	18	18	6			1822½	23.0	0.4
1897	6650		1		4	14	3	27			3	6	8	66	11	25	6	24			3339½	42.8	0.6
1898	20456			1	5	16	21	83	25	3	5	1	4	162	17	49	42	60			6478	82.0	0.4
Total	38295	9	9	8	32	44	27	117	31	6	10	8	22	323	38	88	97	102			13019	164.7	0.4
		85 lb. A.S.C.E. Section. Rolled by Carnegie Steel Co																					
1899	20828				3	51	74	256	300	365	90	13	12	1164	87	165	191	714	7		54368	687.8	3.3
1900	21344					4	80	94	205	499	316	196	108	1510	51	489	365	551	52	2	66573	842.2	3.9
1901	25055						93	341	340	393	402	201	65	1835	20	314	1063	432	3	3	55227	698.6	2.8
1902	21698							17	60	110	127	197	88	599	54	130	211	182	18	4	19423	245.7	1.1
1903	27319								83	245	367	353	280	1328	70	217	438	581	20	7	43491	550.2	2.0
1904	16225									41	142	104	90	377	38	6	159	162	13	1	12302	155.6	0.9
1905	19149										24	45	31	100	41	2	14	40	2	1	3268	41.3	0.2
1906	27084											31	95	126	32	10	39	35	5	5	4192	53.1	0.2
1907	18002												24	24	5	3	5	11			973	12.3	0.1
Total	196702				3	55	257	708	988	1653	1468	1140	791	7063	396	1336	2480	2708	120	23	259817	3286.6	1.7

NOTE
Rails broken or injured by wrecks, broken wheels or similar causes are not included in this report.

(Sample to show how filled in.)

4.

PENNSYLVANIA LINES WEST OF PITTSBURGH
SOUTH WEST SYSTEM

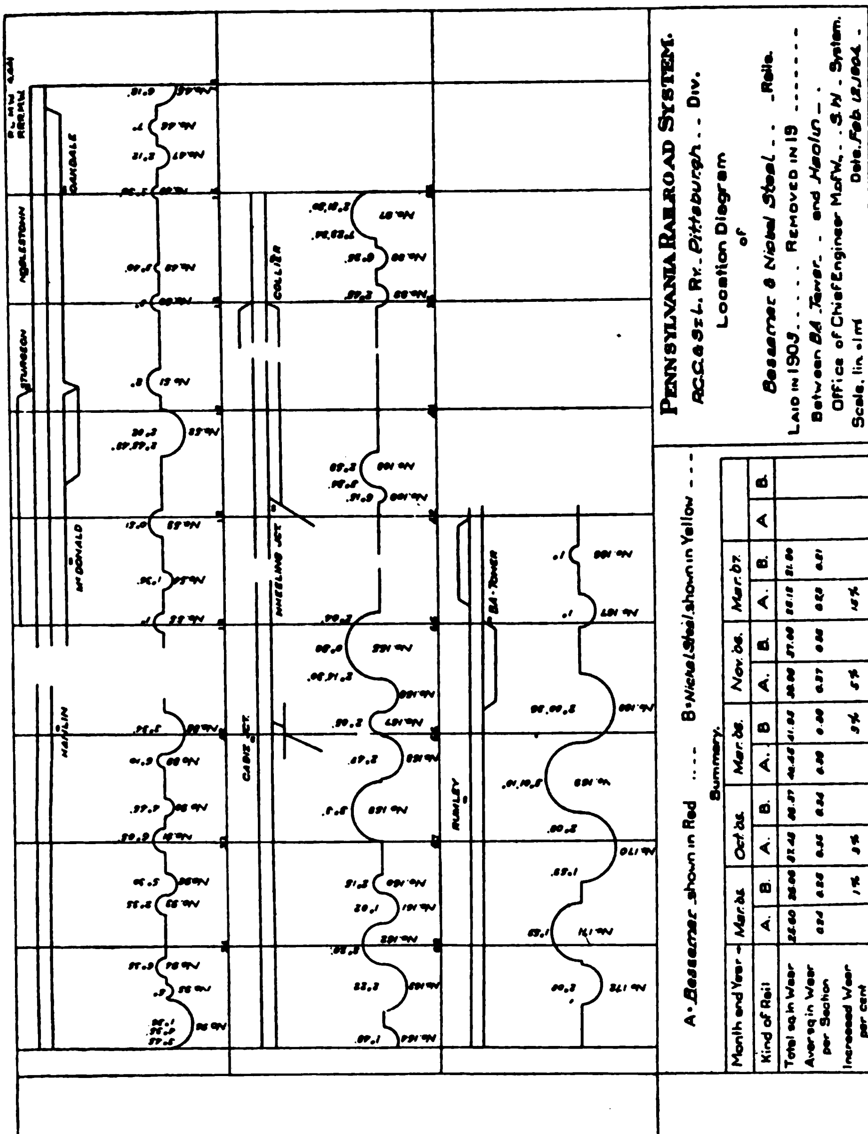
Comparative number of Failures of Steel Rails of Different Section or Pattern, rolled by different Steel Companies.

Record for Period ending Dec. 31, 1907.

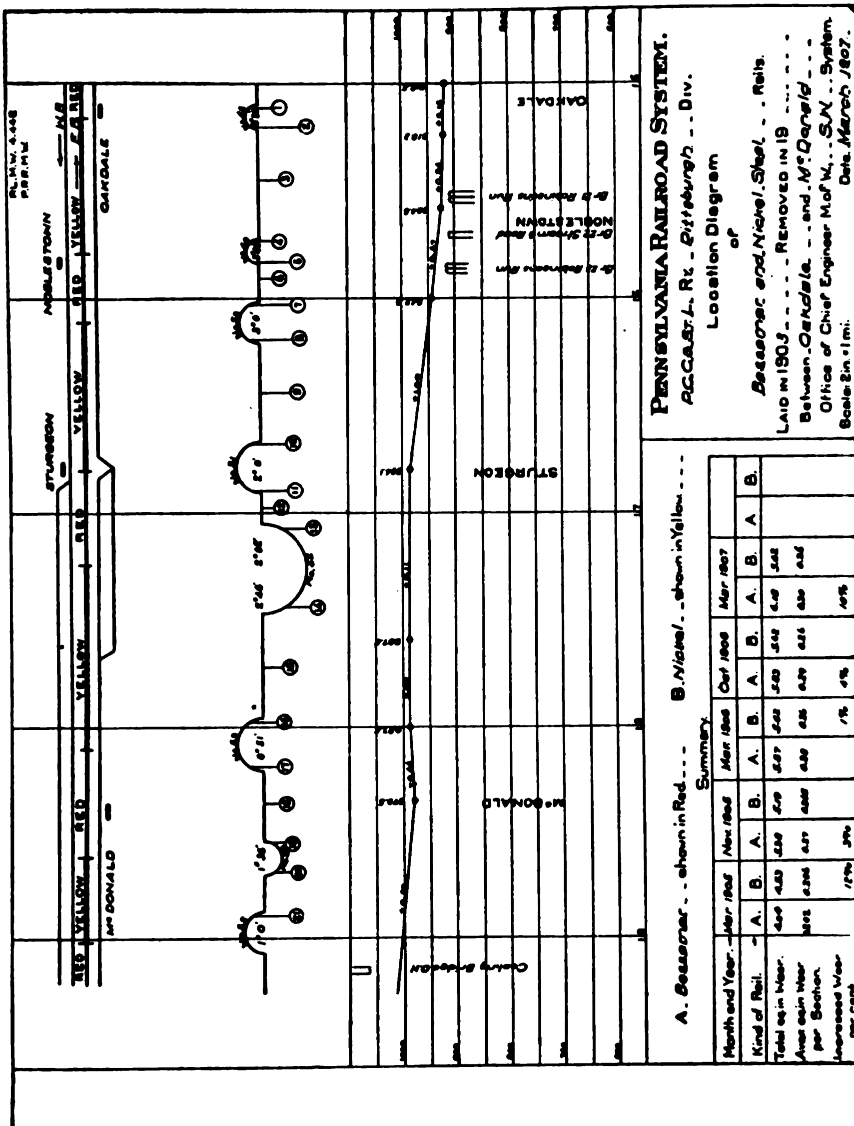
Steel Company and Mill where Rail was rolled	Rail weight per yd lbs.	Rail Section or Pattern	No. of Tons of Rail Laid in Tracks	Kind of Failures: Broken	Flow of Metal	Crushed Head	Split Head	Split Web	Broken Base	Total	Aggregate Tonnage of Rails which Failed	Percentage of Tons Laid
Carnegie Steel Co. Edgar Thompson Mill	100	A.S.C.E	17304	14.9 17	2.6 3	37.7 43	34.2 39	6.2 7	4.4 5	100 114	55.6	0.32
	85	R.R.R.	38295	11.8 38	26.6 86	30.0 97	31.6 102			100 323	164.7	0.4
	85	A.S.C.E	196702	5.6 396	18.9 1336	35.1 2480	38.4 2708	1.7 120	0.3 23	100 7063	3288.6	1.7
Nickel Steel →	85	A.S.C.E	3008	13.3 6		42.2 19	44.5 20			100 45	16.8	0.6
Total			238005	5.9 440	19.1 1422	35.0 2598	38.1 2830	1.6 120	0.3 23	100 7431	3470.3	1.5
Illinois Steel Co. South Chicago Mill	85	R.R.R.	10447	40.8 11	22.2 6	3.7 1	29.6 8		3.7 1	100 27	10.5	0.1
	85	A.S.C.E	15275	23.8 31	16.1 21	30.8 40	26.2 34	0.8 1	2.3 3	100 130	50.3	0.3
McKenna Rerolled →	85	"	480	100 6						100 6	2.1	0.5
Total			26182	29.4 48	16.6 27	25.1 41	25.8 42	0.6 1	2.5 4	100 163	62.9	0.24
Cambria Steel Co. Johnstown Mill	85	R.R.R	2806	80.0 4			20.0 1			100 5	2.3	0.1
	85	A.S.C.E	5055	14.6 6	61.0 25		24.4 10			100 41	22.9	0.5
Total			7861	21.7 10	54.4 25		23.9 11			100 46	25.2	0.3
Lackawanna Steel Co Scranton Mill	85	A.S.C.E	100				100 1			100 1	0.4	0.4
Tennessee Coal and Iron Co.	85	A.S.C.E	480	8.7 2		43.5 10	47.8 11			100 23	9.6	2.0
National Steel Co.	85	A.S.C.E	1305	50.0 1	50.0 1					100 2	0.8	0.1
Summary of all Companies 1895 to 1907 inclusive.	85	R.R.R	51648	14.9 53	25.9 92	27.6 98	31.3 111		0.3 1	100 355	177.5	0.3
	85	A.S.C.E	222385	6.1 448	18.9 1383	34.8 2549	38.1 2784	1.7 121	0.4 26	100 7311	3391.8	1.1
			273933	6.6 501	19.2 1475	34.5 2647	37.7 2895	1.6 121	0.4 27	100 7666	3569.3	1.3

NOTE.
Percentage of "Kind of Failures" shown in red.

(Sample to show how filled in.)



(Sample to show how filled in.)



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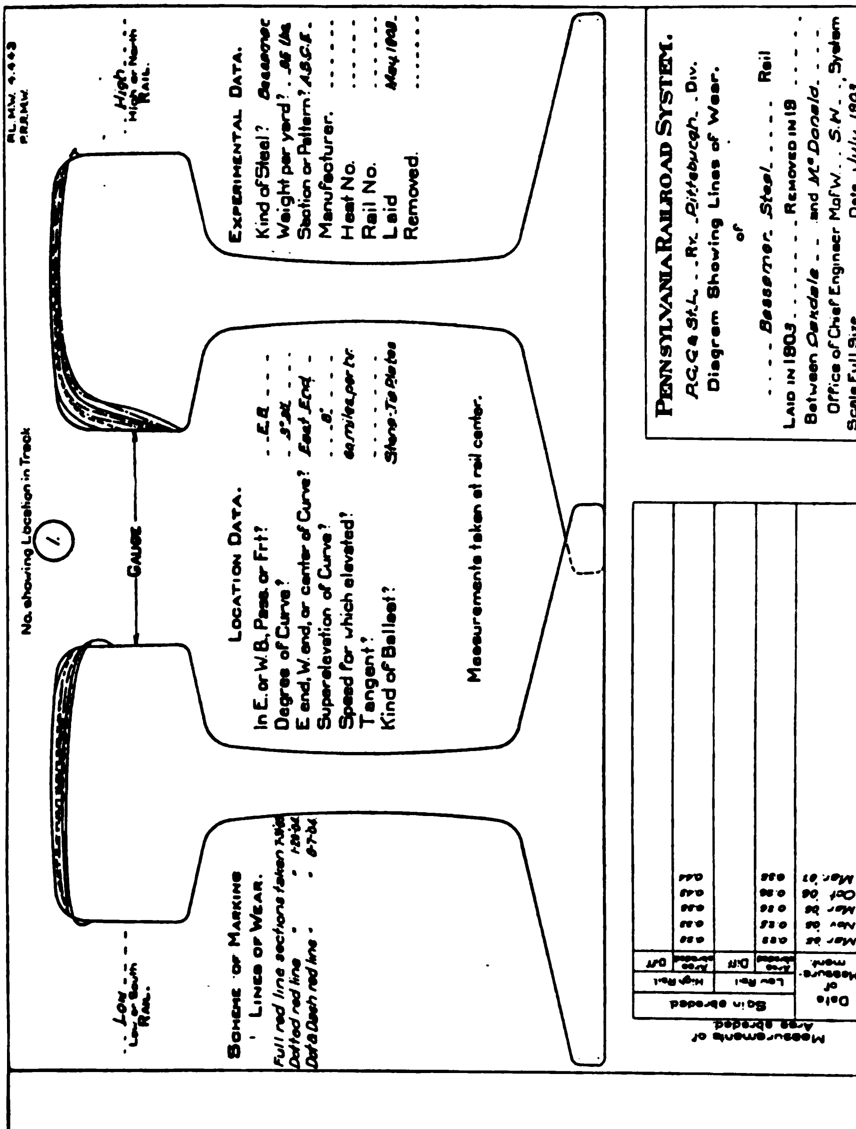


(Sample to show how filled in.)

DROP TESTING MACHINE.

Your Committee considers that a uniform system of testing at the mills is essential. The following specifications for a Standard Drop Testing Machine were submitted by letter-ballot to this Association:

SPECIFICATIONS FOR DROP TESTING MACHINE.

A Drop Testing Machine conforming essentially to the manufacturers' plans and specifications and in general accord with the following requirements will give satisfactory results:

1. The machine shall be arranged to allow a 2000-lb. tup to fall freely at least 25 ft. on the center of a rail resting on supports that can be adjusted to spans varying from 3 ft. to 4 ft. 6 in.

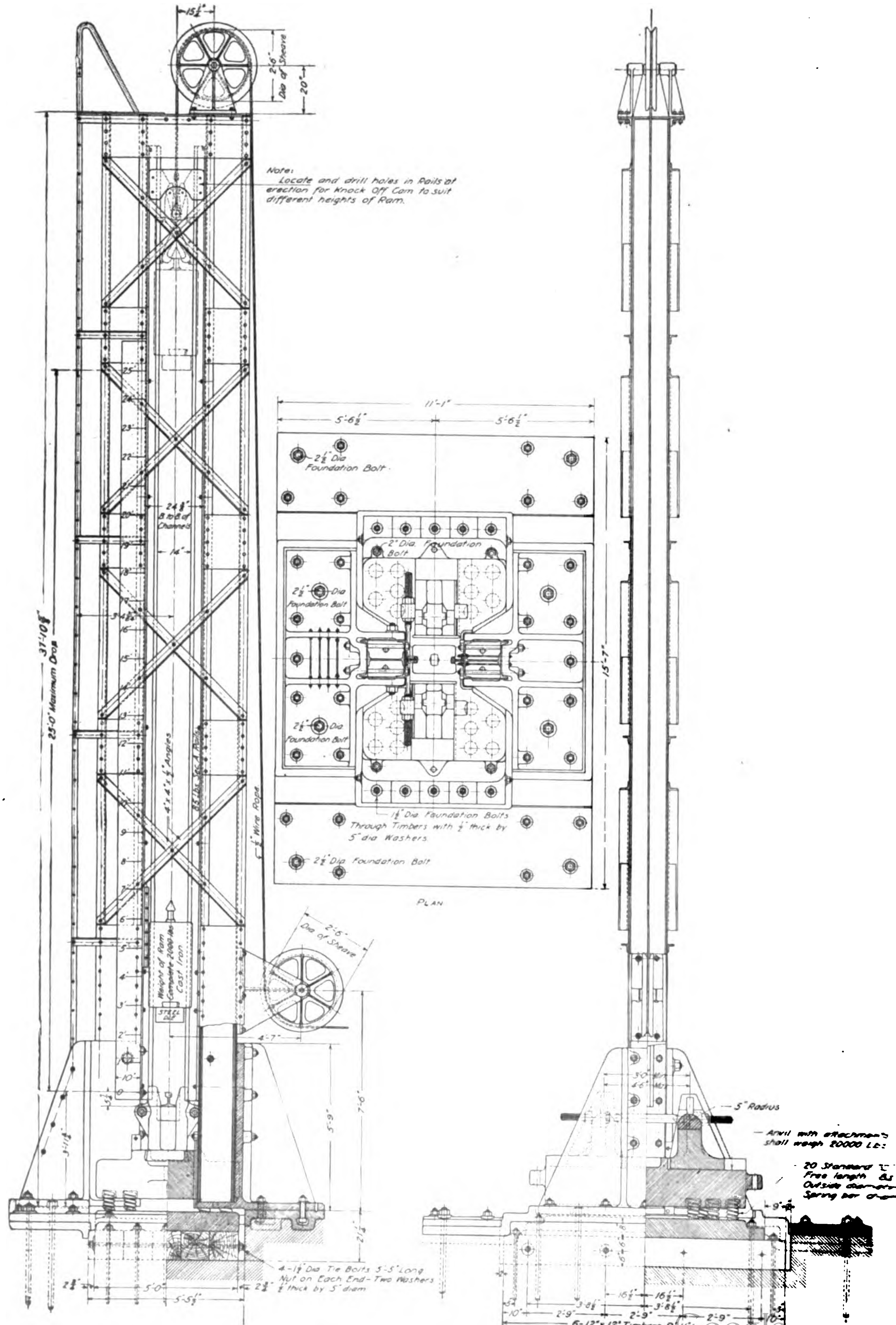
2. The anvil shall be a solid casting, weighing with the attachments that move with it, 20,000 lbs. It shall be free to move vertically independently of the lead columns and shall be supported on 20 springs known as the standard "C" spring, without center coil, as employed by the Master Car Builders' Association (their figure 5614). This spring has a free length of 8¼ in., an outside diameter of 5 7/16 in., and is made from a bar having a diameter of 1 3/16 in. These springs are to be arranged in groups of five at each corner of the anvil and are to be held in place by hubs raised on the top of the base plate and by circular pockets on the underside of the anvil. Removable finished steel wearing strips shall be secured to the anvil and the lead supports for guiding the vertical movement of the anvil.

3. The base plate shall be of cast-iron or cast steel 8 in. thick in the area covered by the anvil. It shall be firmly secured to the substructure by four bolts 2 in. in diameter.

4. The substructure shall consist of a timber grillage resting on a masonry foundation. The grillage shall project 9 in. beyond the ends of the base plate, and clear the columns at the side. It shall consist of one course of 12 in. by 12 in. sound oak or Southern yellow pine, preferably creosoted, laid close and well bolted together. The masonry, preferably concrete, shall be not less than 5 ft. deep below the grillage and be suitably supported on the subsoil.

5. The pedestals for supporting the test rail shall be substantial castings. The rail supports shall be removable pieces of steel, securely held in the pedestals, having an upper cylindrical bearing surface, with a radius of 5 in. The pedestals shall be adjustable to spans varying from 3 ft. minimum to 4 ft. 6 in. maximum between centers. They shall be securely held together, and so fixed to the anvil as to insure that the center of span shall always coincide with the center between leads.

6. The leads shall be firmly connected to the base plate and well braced. They shall be long enough to provide the prescribed free fall of the tup. They shall be provided with a convenient ladder and a



Half End Elevation *Half Section through Center.* *Half Side Elevation* *Half Section through Center.*

plainly marked gage, divided into one-foot intervals. The zero of this gage shall be $5\frac{1}{4}$ in. above the top of the rail supports, and the specified height of drop shall be measured from this zero irrespective of the height of rail being tested. One of the guides shall have a removable section 6 ft. long at the bottom, so that the tup or tripping block can be readily removed.

7. The tup shall weigh, with the accessories that drop with it, 2000 lbs. The striking die shall be steel, having a sylindrical striking face, with radius of 5 in. and a length of 12 in. The guide grooves shall have finished surfaces. The tripping head shall allow a grip of the tongs that will release at the exact height for which the tripping device is set, and that will be safe from accidental release while the test piece is being shifted.

8. The tongs and tripping device shall be arranged to release the tup automatically only; no manual releasing will be allowed. The tripping device shall be easily adjustable at one-foot intervals.

The Committee desires it to be understood that it was not intended to describe in minute detail each part of the Drop Testing Machine, but merely to describe a machine in the essential parts, leaving it optional with the manufacturers to vary in minor details, if found desirable. It may be pertinent to explain that machines similar to the one suggested in the following report have been used for a number of years in testing axles and that the results have been satisfactory. A machine conforming to the requirements set forth herein has been constructed at the works of the Maryland Steel Company, at Sparrows Point, and satisfactory tests have been witnessed by Mr. D. D. Carothers, Chairman, and by Mr. Chas. S. Churchill, member of the Committee. A diagram showing graphically the relation between results of tests as between the old and new methods furnished by Mr. Thos. H. Johnson, member of the Committee, is attached.

Up to the present time, no rail mill has been equipped with a drop testing machine for testing rails that was built on thoroughly scientific principles, owing to the lack of proper foundations or proper anvil, as well as many other essential details. Further, no two rail mills had machines built on even comparatively the same lines. Consequently the results obtained from testing rails in the drop testing machines of any two mills were not comparable, nor were they even correct.

The Manufacturers' Committee, recognizing these defects, prepared specifications and plans of a proposed standard drop testing machine that will give satisfactory and comparable results, and the Rail Committee of the American Railway Engineering and Maintenance of Way Association has, with certain small modifications and additions, approved these plans and specifications and now recommend them for the approval of the Association.

Referring to the plans and specifications, the following is offered by way of explanation:

(a) The object of introducing the springs under the anvil is to create a uniform standard of resistance, which will be the same in all the machines in use at all mills.

(b) Experiments made show that the deflections obtained at different heights of drop with the new standard machine, with its heavy anvil on springs, are greater than those obtained on one of the old style machines with a light anvil not on springs.

(c) The same experiments show that the results on the new machines have a high degree of uniformity, which is lacking in the results of the old machine.

(d) Experience for a number of years with similar machines in testing axles confirm us in the wisdom of using the standard springs as specified.

The Committee has not heard of any argument whatsoever against approving such a standard Drop Testing Machine to be used by all mills in testing rails. The extent to which such a drop testing machine will hereafter be used will depend upon the requirements of the Rail Specifications; but a standard machine is the first essential.

The resolution accompanying the specifications (see Bulletin 102) is as follows:

"Resolved, That a copy of the report of Sub-Committee No. A, on Drop Testing Machine, be sent to the Secretary of the American Railway Engineering and Maintenance of Way Association, with request that the matter be presented to the Board of Direction with request that the same be acted upon promptly and placed before the Association in proper form by letter-ballot for approval, after which it is to be referred to the American Railway Association for approval."

The result of the letter-ballot to November 5, 1908, is as follows:

For Drop Testing Machine Specifications	274
Against	1
Blank	2
Total	277

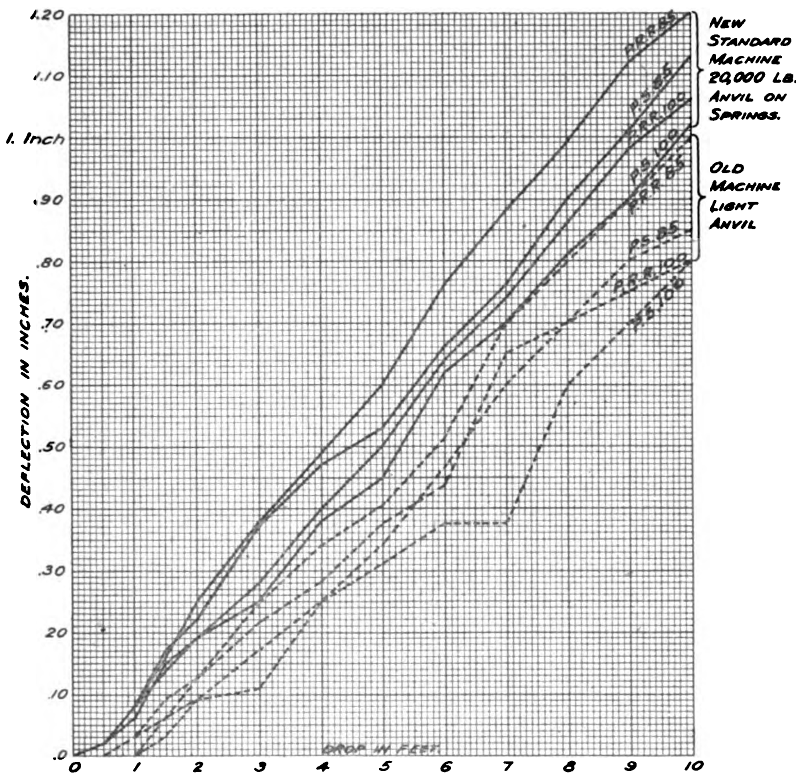
Total mileage in favor of Drop Testing Machine................195,322

RECOMMENDATIONS.

The Committee offers the following resolutions for your approval:

"Resolved, That the specifications and plan for Drop Testing Machine submitted to the Association for letter-ballot (see Bulletin 102) be approved as standard.

"Resolved, That the specifications and plan for Drop Testing Machine be added to the Manual of Recommended Practice."



TESTS ON NEW STANDARD MACHINE.

HEIGHT OF DROP.	P.R.R. 85 LB. SET.	P.S. 85 LB. SET.	P.R.R. 100 LB. SET.	P.S. 100 LB. SET.
6"	.02"	.02"	.02"	.02"
12"	.08"	.08"	.08"	.06"
18"	.16"	.17"	.14"	.15"
24"	.25"	.22"	.19"	.19"
3'	.38"	.37"	.28"	.25"
4'	.49"	.47"	.40"	.38"
5'	.60"	.53"	.50"	.45"
6'	.76"	.66"	.64"	.62"
7'	.88"	.76"	.74"	.70"
8'	.99"	.90"	.86"	.81"
9'	1.12"	1.01"	.98"	.90"
10'	1.20"	1.13"	1.06"	1.02"

TESTS ON OLD STYLE MACHINE.

HEIGHT OF DROP.	P.R.R. 85 LB. SET.	P.S. 85 LB. SET.	P.R.R. 100 LB. SET.	P.S. 100 LB. SET.
6"	0.0"	0.0"	0.0"	0.0"
12"	0.031"	0.0"	0.031"	0.0"
18"	0.093"	0.062"	0.062"	0.031"
24"	.125"	.093"	.125"	.093"
3'	.250"	.171"	.218"	.109"
4'	.343"	.250"	.281"	.250"
5'	.406"	.343"	.375"	.312"
6'	.513"	.468"	.437"	.375"
7'	.700"	.600"	.650"	.375"
8'	.800"	.700"	.700"	.600"
9'	.900"	.800"	.750"	.700"
10'	1.000"	.850"	.800"	.800"

NOTE: These tests were on Rails of the same grade of steel, viz, Carbon about 0.50 and Manganese 0.90 to 1.00. All of these tests were made with a 2000 lb. tup, with radius of striking face 5 inches, and span between centers of supports 3 feet.

With Minutes Atlantic City Meeting, Committee on Rail. June 26 and 27, 1908.

USE OF OPEN-HEARTH STEEL RAILS AND THEIR CHEMICAL COMPOSITION.

Referring to the second instruction, we can only report that we have the matter in mind. Owing to the financial conditions existing during the past year, very little rail has been bought by the railroads of the country. The Committee will secure statistics in the future for rails of special manufacture wherever possible. During the past year a number of roads purchased open-hearth rail, but sufficient time has not elapsed for the Committee to secure the data necessary for a report.

RECOMMENDED CHANGES IN SPECIFICATIONS FOR BESSEMER STEEL RAILS AS HERETOFORE ADOPTED BY THE ASSOCIATION.

A number of specifications are in the field as follows: American Railway Association, American Society of Civil Engineers, American Society of Testing Materials, the Manufacturers', and others besides our own. In view of the fact that the American Railway Association has adopted a specification which has been referred to this Association and that we have been asked to observe the action of rails rolled under the new specifications, it will be some time before definite results and recommendations can be given. Owing to the condition already described, no rails have been rolled according to the American Railway Association specifications, but some rails have been rolled to the new American Railway Association sections.

The Committee offers the following resolutions for your approval:

"Resolved, That the specifications for Bessemer Steel Rail, as presented in the Manual of Recommended Practice, be allowed to remain in the Manual as now printed.

"Resolved, That the following note be added to the specifications in the Manual: (The Committee on Rail has under consideration the matter of revised specifications.)"

Referring to Instruction No. 4, *Present Recommendations as to Standard Rail Sections;* Instruction No. 5, *Present Diagrams or Photographs of Typical Characteristic Rail Failures,* and Instruction No. 6, *Joints,* we can only report progress on these instructions. We have arranged for a series of tests at the Watertown Arsenal of a number of types of rail joints from which we expect to derive some valuable information.

CANTED RAIL.

We have been looking into the matter of Canted Rail and have reports from 190 railways, members of your Association. One hundred and seventy-four roads report no experience, fourteen roads are trying Canted Rails with varying success, and one road is in favor of the plan. Three roads get the cant in the tie plates; the others adze the ties. One road has recently issued instructions for track laying and proposes to cant all its rail.

APPENDIX.

We submit as an appendix to this report a discussion on blanks for reporting rail failures, furnished by Mr. John D. Isaacs, a member of the Committee, in which he outlines the method followed in reporting and studying failed rails on the Harriman Lines.

CONCLUSIONS.

The following conclusions are submitted for your approval:

(1) That the complete set of rail statistic blanks, previously described and approved by letter-ballot, be used by the members of the Association for reporting and compiling information relative to rail failures and rail service.

(2) That Form 2004-A, Summary of Steel Rail Failures for Six Months, Compared with the Same Period of Previous Year; Form 2004-D, Position in Ingot of Steel Rails Which Failed, and Form 2005-D, Record of Comparative Wear of Special Rail, be adopted by the Association as approved forms for receiving statistics for the quantitative study of rail failures.

(3) That the members of the Association furnish the Rail Committee with reports of studies of individual rail failures or rail service, from time to time, as soon as such studies have been made.

(4) That Form M. W. 2003-A, heretofore submitted, be adopted as a standard form of the Association for receiving reports of the Chemical Analysis and Physical Tests of Individual Rails.

(5) That a complete report of the study of an individual rail should consist of—

(a) Copy of the Track Foreman's report on Form M. W. 2002-A, after being checked by an engineer.

(b) Results of Chemical Analysis and Physical Test on Form M. W. 2003-A.

(c) Photographs of the defect or fracture and micro-photographs of the interior structure.

(d) A complete written analysis or deduction from the study of the above information.

(6) That the forms described above and approved by your Association by letter-ballot, also Form 2003-A, be added to the Manual of Recommended Practice.

(7) That the specifications and plan for Drop Testing Machine, heretofore submitted to the Association by letter-ballot, be adopted as standard.

(8) That the specifications and plan for Drop Testing Machine be added to the Manual of Recommended Practice.

(9) That the specifications for Bessemer Steel Rail, as presented in the Manual of Recommended Practice, be allowed to remain in the Manual as now printed.

(10) That the following note be added to the specifications in the Manual: "The Committee on Rail has under consideration the matter of revised specifications."

Respectfully submitted,

D. D. Carothers (*Director*), Chief Engineer, Baltimore & Ohio Railroad, Baltimore, Md., *Chairman.*

R. Montfort, Consulting Engineer, Louisville & Nashville Railroad, Louisville, Ky., *Vice-Chairman.*

Robert Trimble, Chief Engineer Maintenance of Way, Northwest System, Pennsylvania Lines West, Pittsburg, Pa., *Secretary.*

E. B. Ashby, Chief Engineer, Lehigh Valley Railroad, New York, N. Y.

J. A. Atwood, Chief Engineer, Pittsburg & Lake Erie Railroad, Pittsburg, Pa.

A. S. Baldwin, Chief Engineer, Illinois Central Railroad, Chicago, Ill.

J. B. Berry, Chief Engineer, Chicago, Rock Island & Pacific Railway, Chicago, Ill.

Chas. S. Churchill (*Director*), Chief Engineer, Norfolk & Western Railway, Roanoke, Va.

W. C. Cushing (*Director*), Chief Engineer Maintenance of Way, Southwest System, Pennsylvania Lines West, Pittsburg, Pa.

F. A. Delano, President, Wabash Railroad, Chicago, Ill.

Dr. P. H. Dudley, Rail Expert, New York Central Lines, New York, N. Y.

C. H. Ewing, Engineer Maintenance of Way, Philadelphia & Reading Railway, Reading, Pa.

J. F. Hinckley, Chief Engineer, Frisco Railway System, St. Louis, Mo.

John D. Isaacs, Consulting Engineer, Harriman Lines, Chicago, Ill.

Thos. H. Johnson, Consulting Engineer, Pennsylvania Lines West, Pittsburg, Pa.

Howard G. Kelley (*Past-President*), Chief Engineer, Grand Trunk Railway System, Montreal, Canada.

J. W. Kendrick, Second Vice-President, Atchison, Topeka & Santa Fe Railway, Chicago, Ill.

George W. Kittredge (*Past-President*), Chief Engineer, New York Central & Hudson River Railroad, New York, N. Y.

D. W. Lum, Chief Engineer Maintenance of Way and Structures, Southern Railway, Washington, D. C.

Jos. T. Richards, Chief Engineer Maintenance of Way, Pennsylvania Railroad, Philadelphia, Pa.

J. P. Snow (*First Vice-President*), Bridge Engineer, Boston & Maine Railroad, Boston, Mass

Committee.

Appendix A.

METHOD OF REPORTING AND STUDYING FAILED RAILS ON HARRIMAN LINES.

October 5, 1908.

To the Chairman and Members of the Committee on Rail, American Railway Engineering and Maintenance of Way Association:

Gentlemen:

The purpose of this paper is to outline the method followed in reporting on and studying failed rails on the Harriman Lines. The practice on the various portions of these Lines varies slightly, but in general may be summarized as follows:

There are but two forms in use:

(1) The Section Foreman's Form, No. 2658, attached. This is used as follows: When a broken or failed rail is found the Section Foreman fills out this form and forwards it so filled out to the Roadmaster; the Roadmaster certifies to this report, makes a press copy of it, and sends it to the Division Engineer, who in turn takes his record therefrom and transmits the form to the Division Superintendent. At the same time that the Section Foreman makes out his report, all broken or failed rails when removed from the track are marked with white paint, showing from which section taken, the location by mile post or station and plus, also weight and brand of rail. All broken and failed rails and the pieces thereof are sent to some Division Terminal, the Division Terminals being selected as the most central and convenient for inspection and taking samples. The Roadmaster, or other engineer, whose business it is to inspect these rails, is furnished with a copy of the Superintendent's report of broken or failed rails, hereafter referred to, in order that these rails may be identified and properly reinspected by him, and such corrections made in the Foreman's report as may be necessary. Borings are made from at least 10 per cent. of broken rails in accordance with footnote on Form 2736; these borings, properly marked, are sent to the General Officer in charge of maintenance, who transmits them to the Engineer of Tests, through the Superintendent of Motive Power.

(2) The Foreman's reports, Form 2658, are held in the Division Superintendents' offices until the end of the month, when a general report is made by the Division Superintendent on Form 2736, embodying all the information on Foremen's reports, Form 2658. The Division Superintendent's report includes all the information in columns 1 to 15 inclusive; also in columns 18 and 21. The Division Superintendent's report, so made out, is transmitted to the Chief Engineer, or other General Officer in charge of maintenance, in whose office columns 16 and 17 and 19 and 20 are filled out. The Engineer of Tests, through the

Superintendent of Motive Power, sends to the Chief Engineer, as above, the information necessary to fill out columns 19 and 20.

(3) The Chief Engineer's report, Form 2736, so completed, is forwarded either directly to the General Manager, or through the General Superintendent to the General Manager, and thence to the office of the Consulting Engineer.

These reports, which will in the future be slightly modified so as to include a statement as to whether broken rail was on the inside or outside of curve, and from what portion of ingot rolled, seem to include all the information necessary or desirable to be given in regard to the facts connected with broken or failed rails from the time they are discovered in the track until a complete report is filed.

Upon receipt of this information the Consulting Engineer makes a monthly report to the Director of Maintenance and Operation, consisting of two parts: First, a statement of broken and failed rails, giving the railroad, the number of failed rails, and the number of failures per 100 miles of track, the percentage of failures of each weight due to defects, and the percentage of failures of all weights due to defects; the second part is the same information segregated as to the name of the manufacturer or rolling mill in which these rails are made. The accompanying sheets are actual reports for the month of June, 1908, with the names of railroads and those of the manufacturers indicated by letter.

For the year 1907 all these monthly reports have been collected, tabulated, and put into the form of charts bound together with a statement of conclusions for convenient reference and study.

Hereafter this information will be collected at intervals of six months instead of annually, and the charts made out not only for the individual half years but also annually for all preceding years back to and including 1907.

It seems to us that this is the best method so far presented for generalizing upon the information received.

From the diagrams and facts presented, our principal troubles as regards failed rails appear to be as follows:

(1) Cold weather.

(2) Ninety-pound section.

(3) Newly laid rails.

(4) Balls and flanges of 90-lb.; ball of 75 and 80-lb.

(5) Excess of phosphorus.

(6) 90-lb. manufactured by "A" Steel Company; 75-lb. by "D" and "E" Companies.

Special attention is called to the fact that the number of failures of the 90-lb. section per 100 miles of track is much greater than the 75 and 80 under the same tonnage, and that 77 per cent. of the failed rails which were analyzed contained phosphorus in excess of .085.

Respectfully submitted,

(Signed) JOHN D. ISAACS.

Form 2658.

FOREMAN'S REPORT OF BROKEN OR *FAILED RAILS.

..............................Division.

....190..

....District on Sec. No............

Between Mile Post...............................and...................

Discovered .... 190..

at.............o'clock....M.

By ....

1. Brand in full...

....

2. Weight of rail per yard..
3. Whole length of rail...
4. Lengths of pieces ....
5. Were pieces in or out of place?......................................
6. Was rail battered at break?..
7. Was break on or between ties?..
8. What train broke rail?...
9. What accident resulted from break?...................................
10. Cause of removal (if broken rail, supposed cause of breaking)......

....

....

....

....

11. Suspended or supported joint..
12. Anglebar, fishplate or continuous joint.............................
13. Was rail battered, or split, at joint?..............................
14. Was rail near station or stopping point?............................
15. North or South rail?..
16. On curve or tangent?..
17. Was rail well surfaced and lined?...................................
18. Was rail full spiked?...
19. Kind and condition of ties..
20. Kind and condition of ballast.......................................

Remarks..

....

....

....

....

....Roadmaster.

....Foreman.

NOTE.—*Failed Rail is any rail removed for cause from main track within five years of time it was laid or BRANDED.

Fill out above form in copying ink, fold lengthwise, and forward by first train to Roadmaster.

Roadmasters, please take impression for your record, endorse, and forward this report to Superintendent of your division.

Form 2736 C.S

STATEMENT OF BROKEN OR FAILED RAILS

PERIOD ENDING________________190__

Name of Road	Division	Location Mile Post or Station	"T" Tangent "C" Curve Degree	FAILURE				LENGTH		Wght.	Section	BRAND			Inspt. by	How Long in Track Yrs. Mos.	Disposal of Broken Pieces	Etching or Sketch Number	Chemical Analysis 20					Tonnage
				Date	Cause	Longitudinal or Cross Break	Description	Original	Broken Pieces			Mill	Heat Number	Year					C	P	Si	Mn	S	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19						21

1. Describe Breaks (Column 8) as Follows:

1a. Longitudinal Breaks:—Whether split ball, split flange, split web; piece broken out of ball, flange or web; piped material; old cracks.

If observable cause other than those above, note same; if not observable cause, state "Unknown."

1b. Cross Breaks:—Piped section; glassy section, indicating brittleness; granular section, indicating short fiber; flaws; old cracks.

If observable cause other than the above, note same; if no cause observable, state "Unknown."

1c. Battered:—Battered ends; bent over sideways, or otherwise distorted; corrugated ball.

2. Analysis, Column 20.

Have borings made from about 10% of broken rails at break, selecting pieces indicating brittle or soft structure provided there should never be less than six samples taken, should so many rails be broken. These borings should be sent to the Engineer of Tests.

Upon receipt, the Engineer of Tests will make analysis showing the following chemical characteristics, in the following order:

1	Carbon,	per cent (Designated as	C)
2	Phosphorus,	" " ("	" P)
3	Silicon,	" " ("	" Si)
4	Manganese,	" " ("	" Mn)
5	Sulphur,	" " ("	" S)

The results of these analyses are to be entered in Column 20.

3. Etchings:—Select six broken rails (should there be so many broken) showing typical breaks, such as pipes, splits, hard or coarse fiber. From each rail, saw off short samples so as to give a complete cross section at one end of the sample; forward these samples to the Engineer of Tests for etching and analyzing. Upon receipt, Engineer of Tests should etch the samples and make prints therefrom, and attach to each print a complete analysis of borings from the same test piece, as directed in clause 2. The etchings should be identified by suitable note designating the broken rail from which taken.

4. Disposal of Broken Pieces, Column 18:

State whether used in track, or sent in to Store Department for future claims.

5. Give total number of rails of each section in track within the district for which failed rails are given, so that computations can be made of ratio of failed rails to total number of rails in use of same section in same district.

6. Tonnage, Column 21:—Give total tonnage carried by failed rails to date of failure, in units of one million tons.

Remarks:...

....

STATEMENT.

BROKEN OR FAILED RAILS, MONTH OF JUNE, 1908.

Railroad.	Defective.			Other Causes.			Number of Failures per 100 miles Track.		
	75 lb.	80 lb.	90 lb.	75 lb.	80 lb.	90 lb.	75 lb.	80 lb.	90 lb.
V	1	8	20	......	19	2	0.40	2.78	3.77
W	......	......	......	......	2	......	......	0.26	......
X	1	2	......	......	......	......	0.21	0.48	......
Y	......	5	......	2	3	......	0.36	0.76	......
Z	33	5	......	14	7	......	3.80	0.85	......
All Lines........	35	20	20	16	31	2	1.82	1.10	2.71

Percentage of failures due to defects, 69 per cent, 40 per cent, 91 per cent.
Percentage of failures of all weights due to defects, 60 per cent.

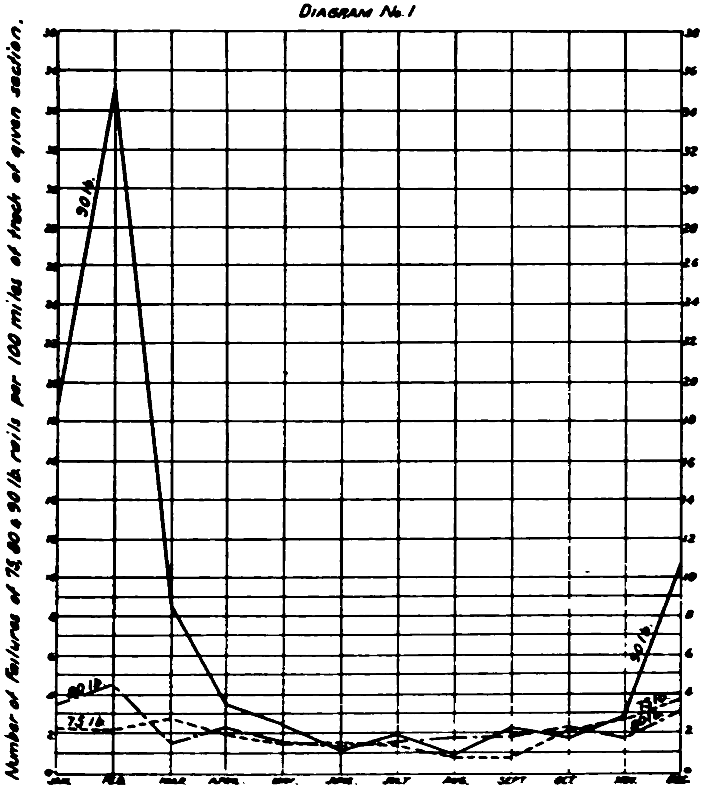
BROKEN RAILS ON ALL LINES OF DIFFERENT MANUFACTURE, JUNE, 1908.

Name of Manufacturer.	75 lb.			80 lb.			90 lb.		
	Miles.	No. Brk.	Per 100 m.	Miles.	No. Brk.	Per 100 m.	Miles.	No. Brk.	Per 100 m.
A	1909.5	44	2.3	1321.4	15	1.1	323.8	0	......
B	320.2	0	......	1351.2	12	0.9	267.2	7	2.6
C	260.6	1	0.4	1057.8	18	1.7	131.5	1	0.7
D	76.5	4	5.2	120.9	0	......	15.8	0	......
E	45.3	1	2.2	....	......	......	....	......	......
F	6.1	0	......	303.5	2	0.7	55.8	0	......
G	79.1	0	......	22.5	0	......	....	......	......
H	....	......	......	417.7	2	0.5	....	......	......

FAILURES ON ALL LINES—YEAR 1907.

Life.	Failures per 100 Miles for Certain Life.		
	75 lb.	80 lb.	90 lb.
Less than 6 months	4.40	.10	10.73
Less than 1 year............	5.74	.43	61.91
Less than 2 years...........	6.61	6.11	80.94
Less than 3 years...........	6.94	10.76	88.90
Less than 4 years...........	7.15	16.80	.....
Less than 5 years...........	7.56	20.26	.....
Less than 10 years..........	17.18	25.24	.....
Over 10 years...............	22.13	25.26	.....

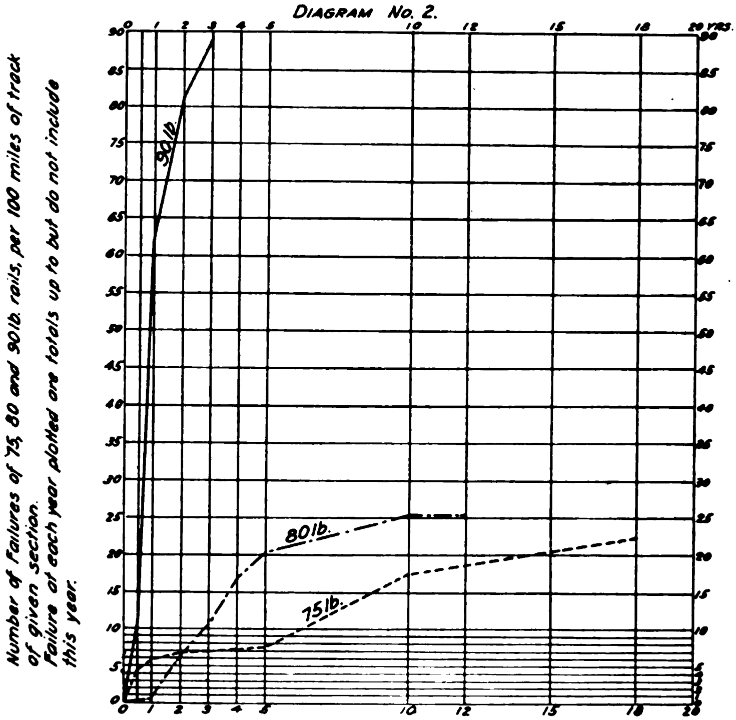
DIAGRAM No. 1



FAILURES ON ALL LINES DURING YEAR 1907.

This diagram is compiled to show the distribution of total rail breakages for all lines for the year 1907 with respect to the various months. EXAMPLE: Diagram shows that for the month of February we have 35 broken 90 lb rails for each 100 miles of 90 lb section in the track; 4.7 broken 80 lb rails per 100 miles of 80 lb rail in the track, and 2.1 broken 75 lb rails per 100 miles of 75 lb rail in track.

CONCLUSIONS: The diagram would seem to indicate that for all weights of rail and more especially for the 90 lb section, the larger number of breaks took place during the colder months of the year.



LIFE OF RAILS.
Failures on all Lines during year 1907.

This diagram shows the life of 75, 80 and 90lb. rails which failed on all lines during the year 1907.

EXAMPLE:

Diagram shows 80.9 broken 90lb. rails lasting less than two years, for each 100 miles of 90lb. rail in track; shows 6.1 broken 80lb. rails lasting less than two years for each 100 miles of 80lb. rail in track; and 6.6 broken 75lb. rails lasting less than two years for each 100 miles of 75lb. rail in track.

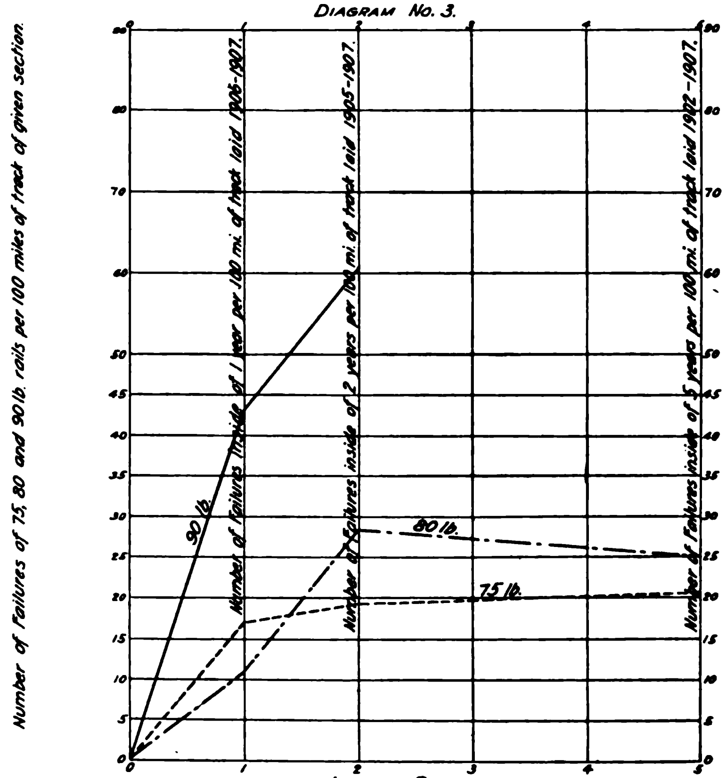
CONCLUSIONS:

The diagram indicates that for the rail breakages for 1907 the majority of 90lb. breakages were of rails less than one year old; shows very few 80 lb. rail breakages of rail less than one year old, but shows a larger number of 80lb. breakages between the ages of one and four years.

A large number of broken 75lb. rails were less than six months old. Very few of the 75lb. rails broken were between one and five years old, the greater number of breaks being of rails from five to ten years old.

This table takes no account of the relation of the breakages to the number of new rails laid, but simply indicates the life of the broken rails during 1907. It clearly indicates that the 90lb rails are failing at a considerably greater rate than either the 80 or 75lb., and that there was a greater percentage of 80lb. broken rails less than five years old than of 75lb.

DIAGRAM No. 3.



LIFE OF RAILS.
Failures on all Lines during year 1907.

This diagram is intended to show the comparative rate of breakage of the new 75, 80 and 90 lb. rail.

CONCLUSIONS:

Diagram indicates that with all weights of rail the breakage is high during the first two years of life, probably due to a weeding out of defective rails. The rail failures during the first year is highest on the 90, next on the 75 and lowest on the 80.

The rate of failure during the first two years is for the highest on the 90, next on the 80 and lowest on the 75. Between the second and fifth year of life the rate of failure was very low for the 75 and 80 lb. rail, but we have no record up to the present time of the 90 lb.

Table 3 is intended as a supplement to table 2, and the two tables taken together show decidedly that a weeding out process rapidly takes place when new rails are laid, due, no doubt, to defective rails; and the fact is also brought out that the new 90 lb. rails are proving inferior under the same traffic to the new 75 and 80 lb. rails.

FAILURES PER 100 MILES OF 75, 80 AND 90 LB. RAILS FOR YEAR 1907.

Life of Rails. Years.	75 lb.		80 lb.		90 lb.	
	No.	Per 100 miles.	No.	Per 100 miles.	No.	Per 100 Miles.
Less than 1 year............	135	17.0	21	11.0	334	43.2
Less than 2 years...........	156	19.3	289	28.3	469	60.7
Less than 5 years...........	178	20.5	940	25.0	....	....
Miles of rail laid last 2 years..	797.58		192.86			
Miles of rail laid last 3 years.	807.09		1020.80			
Miles of rail laid last 6 years..	868.76		3773.72			
Miels in track Dec. 31, 1907...	2326.0		3941		6	

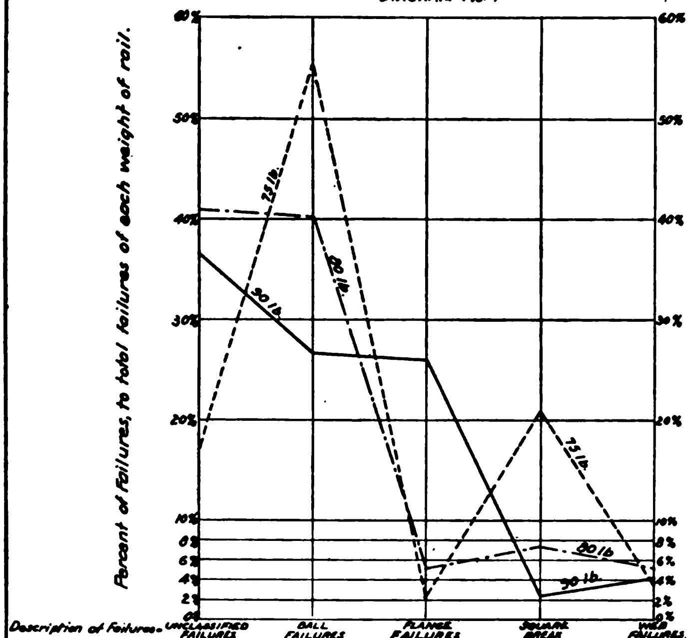
MILES OF RAILS LAID DURING FOLLOWING YEARS.
ALL LINES.

Year.	75 lb.	80 lb.	90 lb.
1907	467.75	3.08	282.49
1906	329.83	189.78	492.36
1905	9.51	827.94	......
1904	21.02	762.37	......
1903	12.69	1003.18	......
1902	27.96	987.37	......
Total	868.76	3773.72	774.85
Miles in track Dec. 31, 1907	2326	3941	756

PER CENT. OF FAILURES OF VARIOUS DESCRIPTIONS.
ALL LINES—YEAR OF 1907.

Description.	75 lb.		80 lb.		90 lb.	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Unclassified	92	17.2	498	41.2	190	36.6
Ball Failures	295	55.3	489	40.4	148	28.5
Flange Failures	12	2.2	66	5.4	146	28.1
Square Breaks	113	21.2	93	7.7	13	2.5
Web Failures	21	3.9	66	5.4	22	4.2
Total	533	100	1212	100	519	100

DIAGRAM No. 4



Failures on all Lines during year 1907.

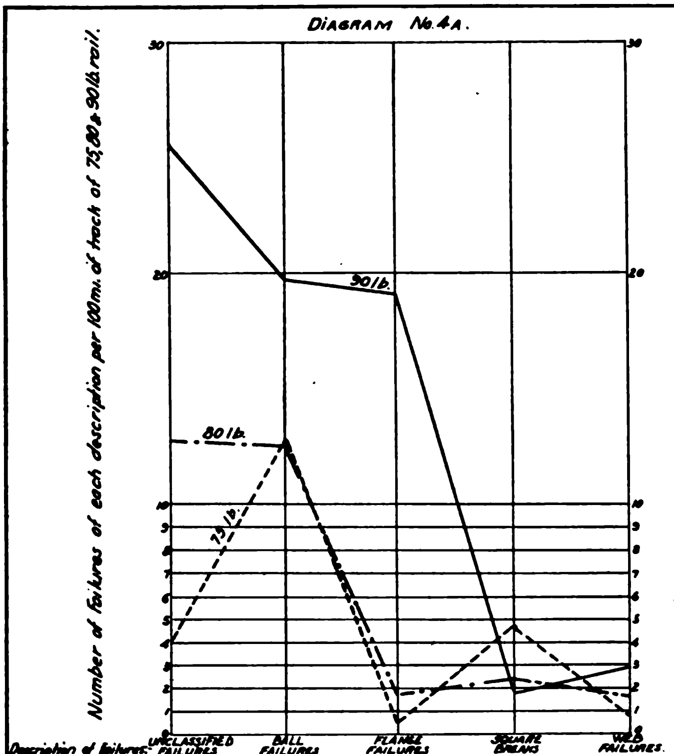
This diagram indicates the percentages of failures of various descriptions for the 75, 80 and 90 lb. rail.

EXAMPLE: Ball Failures. Shows 55.3% of the failures for the 75 lb. were in the ball, 40.4% of the failures of the 80 lb. rail were in the ball, and 28.5% of the failures of the 90 lb. rail were in the ball.

CONCLUSIONS: The majority of the unclassified breaks are stated as due to defects flaws, or are classified as irregular breaks or splits, there being nothing on the reports to show what part of the rail was split. The diagram indicates that the ball failures are the most serious, which is to be expected, but it also shows that the percentage of ball failures is higher on the 75 lb. rail than on the 80, and ball failures on 75 and 80 are both higher than the ball failures on the 90 lb. rail. This would appear to be consistent considering the sizes of rail heads.

FLANGE FAILURES: Shows a much greater percentage of flange failures on 90 lb. rail than on either the 80 or 75, which would seem to bear out the assertion made that the flange of the 90 lb. rail is one of the weak points in the larger section a brittleness being produced by the quick cooling of the thin flange.

SQUARE BREAKS: The percentage of square breaks is highest on the 75 lb. rail, next on the 80 and least on the 90, which would seem to be consistent, 75 lb rail of course being a much weaker structure than 80 lb. and the 80 being weaker than the 90. Diagram indicates that comparatively little trouble has been experienced with the web of any section.



Failures on all Lines during year 1907.

This diagram is made up from the same information as Diagram 4. except that each class of break is divided by the number of miles of that weight of section in the track.

EXAMPLE: Ball Failures. We had 19.6 90 lb. ball failures for each 100 miles of 90 lb. rail in the track; 12.4 80 lb. ball failures for each 100 miles of 80 lb. rails in track and 12.7 75 lb. ball failures for each 100 miles of 75 lb. rails in the track.

CONCLUSIONS:

Diagram shows the ball failures for the 90 lb. rail are considerably higher than for the 75 and 80 lb. rail, which are about the same. Diagram shows flange failures for 90 lb. rail are ten times as high as the flange failures for 80 lb. rail, and forty times as high as failures for 75 lb. rail, which, with diagram No. 4. seem to point decidedly to a brittleness or weakness in the flange of 90 lb. rail.

The square breaks are comparatively low for all three sections, although they are highest on the 75 lb., which would seem to be consistent, as the 75 lb. is a weaker structure than the 80 or 90 lb.

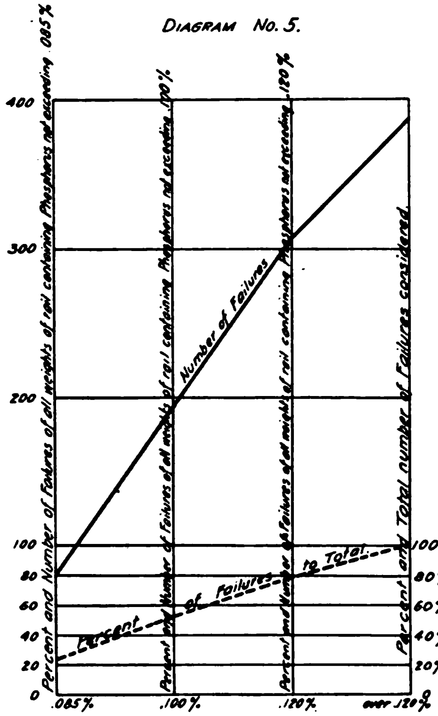
The web failures are comparatively low for all three sections.

The unclassified failures are very high on the 90 lb.

FAILURES ON ALL LINES DURING YEAR 1907.

Description.	75 lb.		80 lb.		90 lb.	
	No.	Per 100 Miles.	No.	Per 100 Miles.	No.	Per 100 Miles.
Unclassified................	92	4.0	498	12.6	190	25.2
Ball Failures................	295	12.7	489	12.4	148	19.6
Flange Failures.............	12	0.5	66	1.7	146	19.3
Square Breaks..............	113	4.8	93	2.4	13	1.7
Web Failures................	21	0.9	66	1.7	22	2.9
Total..................	533	22.9	1212	30.9	519	68.7
Miles in track Dec. 31, 1907................		2326		3941		756

Diagram No. 5.



Percent of Phosphorus.

Failures on all Lines during the year 1907.

392 Broken Rail Analyses Considered.

Diagram No. 5 shows the Phosphorus content for all weights of rail for all broken rails analyzed during the year 1907 for all lines.

Conclusions:

Out of 392 broken rails analyzed but 91, or 23%, fulfilled the requirements for Phosphorus, containing less than .085%; 197, or 50%, had Phosphorus less than .100%; 303, or 77%, contained Phosphorus less than .120%; and 89 failures contained Phosphorus over .120%.

ALL WEIGHTS OF RAIL FAILURES ON ALL LINES—YEAR 1907.

Per Cent. Phosphorus.	Number.	Failures.	Per Cent.
Not exceeding .085%.....	91	91	23%
Not exceeding .100%.....	106	197	50%
Not exceeding .120%.....	106	303	77%
Over .120%.............	89	392	100%

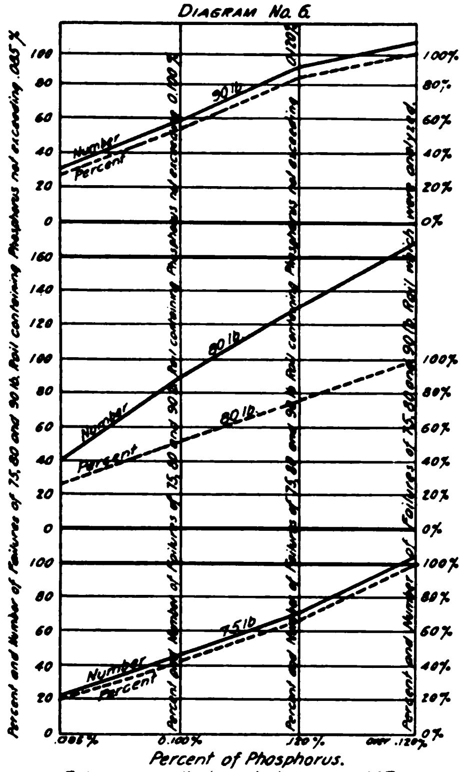
FAILURES ON ALL LINES—YEAR 1907.

Per Cent. of Phosphorus.	75 lb.			80 lb.			90 lb.		
	No.		Per Cent.	No.		Per Cent.	No.		Per Cent.
Not exceeding .085%........	20		19	40		24	26		25
Not exceeding .100%........	25	45	44	47	87	53	32	58	55
Not exceeding .120%........	25	70	68	40	127	77	34	92	87
Over .120%................	33	103	100	38	165	100	14	106	100
Total..................	103			165			106		

BROKEN RAILS ON ALL LINES, YEAR 1907, OF DIFFERENT MANUFACTURE.

Manufacturer.	75 lb.			80 lb.			90 lb.		
	Miles.	No. Brk.	Per 100.	Miles.	No. Brk.	Per 100.	Miles.	No. Brk.	Per 100.
A...........	1847.	428	23.2	1312.	550	42.0	337.5	343	102.
B...........	256.7	12	4.7	1330.	293	22.0	278.6	105	37.3
C...........	154.1	5	3.3	1112.	245	22.0	115.4	3	2.6
D...........	43.65	18	41.3	120.9	9	7.5	8.00	0	......
E...........	45.33	22	48.5	0.	2	......	0.	0	......
F...........	6.12	0	......	300.9	29	9.7	55.8	3	5.4
G...........	41.01	2	4.9	77.8	2	2.6	0.	0	......
H...........	0.	0	......	423.7	16	3.8	0.	0	......

DIAGRAM No. 6.



Failures on all Lines during year 1907.

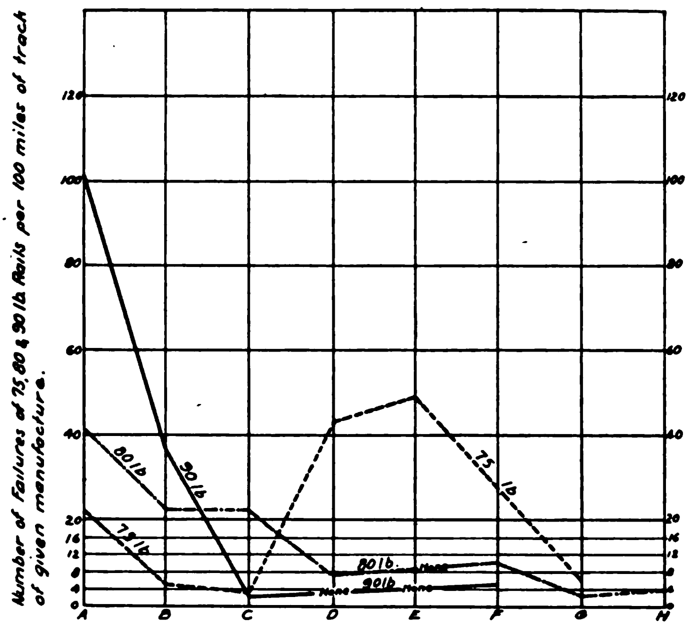
103	Failures	75 lb.	Rail Analyses Considered
165	"	80 "	" " "
106	"	90 "	" " "

Diagram No. 6 is the same as Diagram No. 5 except that the weights of rails are segregated.

Of 103, 75 lb. broken rails analyzed, but 20, or 19%, contained the required amount or less of Phosphorus (.085%). Of the 165, 80 lb. broken rails analyzed, but 40, or 24%, fell within the Phosphorus limits required. Of the 106, 90 lb broken rails analyzed, but 26, or 25% fell within the required limits of Phosphorus.

Diagram Nos. 5 and 6 considered together show that the Phosphorus content in the majority of rails is excessive. But it does not show the Phosphorus content much more excessive for any particular section. We might infer from this that excessive Phosphorus may not be the explanation of the greater number of breakages in the 90 lb. rail

DIAGRAM No. 8.



NAME OF MANUFACTURER

Failures on all Lines during year 1907.

Note: "None" indicates "No appreciable amount of this weight and make in track.

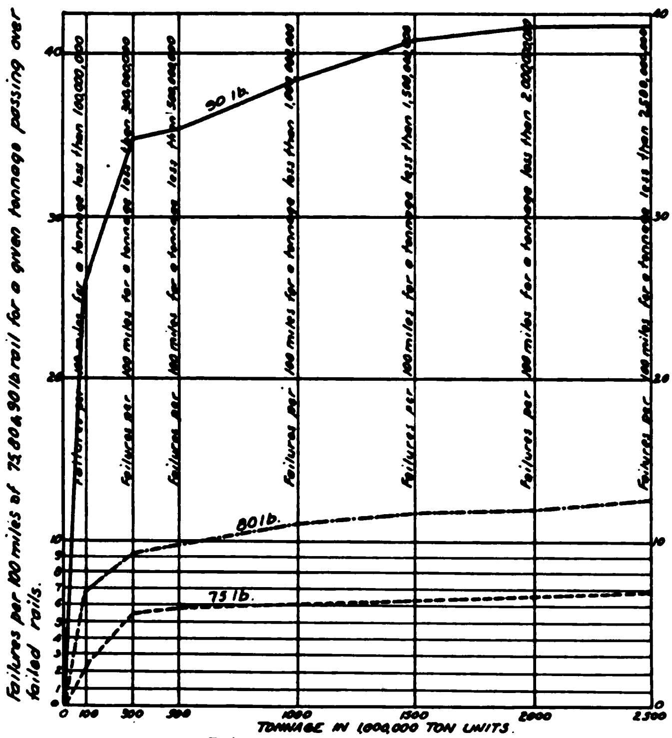
This diagram is intended to show the number of breaks per 100 miles of 75, 80 and 90 lb rail, segregated as to the different manufacturers.

CONCLUSIONS:

Too much dependence cannot be placed upon this diagram owing to the wide variation in mileage of the different makes, in most cases the larger number of breaks per 100 miles occurring in the weight and make where the mileage is the largest. Seventy-five pound rails from Manufacturer "D" and "E" show a high percentage of breaks, but we have only 43 miles of "D" 75 lb. rails and 45 miles of "E" 75 lb. rails in the track as against 1847 miles of 75 lb "A".

Of the 90 lb. rail we have 337.5 miles of "A", 278.6 miles of "B", and 1154 miles of "C", so that these may be very well compared. Diagram shows that during the year 1907 we had 102 breaks per 100 miles of "A" rail, 37 of "B", and but 2.6 of "C". The probable explanation for the low breakage of the "C" is no doubt due to the fact that the majority of this rail was laid in the latter part of the year 1907 and had very little usage during the year. The fact that these 90 lb rails from "C" were Open Hearth Steel while those from "A" and "B" were Bessemer Steel may have some bearing in this matter, but the rails have been in service too short a time to draw any definite conclusions.

DIAGRAM No. 9.



Failures on all Lines during year 1907.

This diagram is compiled to show the rate of failure of the rails as regards the tonnage which has passed over them.

CONCLUSIONS:-

If the rails were acting properly - that is, were wearing out, the rate of breakages should increase with the tonnage, but the facts show that this is not the case. The majority of failed rails for 75, 80 and 90 lb. rail have failed before 300.000,000 tons have passed over them, and between 300.000,000 and 2,500,000,000 the rate of breakage has decreased. This would seem to indicate that the new rails are defective. With the same tonnage in either case the rate of failure of the 90 lb. rail is much higher than the rate of failure of the 80 lb. rail, and the rate of failure of the 80 lb. rail is higher than the rate of failure of the 75 lb rail, which seems to show that the 75 lb rail is standing up better under traffic than the 80, and more especially than the 90 lb.

FAILURES ON ALL LINES DURING YEAR 1907 FOR GIVEN TONNAGE.

Tonnage in 1,000,000 Ton Units.	75 lb.			80 lb.			90 lb.		
	No.	Total.	Per 100 M.	No.	Total.	Per 100 M.	No.	Total.	Per 100 M.
Less than 100	54	54	2.3	266	266	6.8	197	197	26.1
100–300	74	128	5.5	93	359	9.1	67	264	34.9
300–500	9	137	5.9	20	379	9.6	2	266	35.2
500–1000	5	142	6.1	55	435	11.0	26	292	38.6
1000–1500	3	145	6.3	22	457	11.6	16	308	40.8
1500–2000	9	154	6.6	8	465	11.8	5	313	41.4
2000–2500	5	159	6.9	16	481	12.2	0	313	41.4
Mileage Dec. 31, 1907.		2326			3941			756	

DISCUSSION.

Mr. Chas. S. Churchill (Norfolk & Western):—The work assigned to this Committee is outlined briefly in Bulletin 102 under six heads. In carrying out these instructions there were three sub-committees appointed, with Messrs. Atwood, Berry and Cushing as chairmen. The progress of the work under these six heads has been as rapid as possible, considering the difficulties that confronted the Committee. These difficulties, briefly, are that no systematic method was being followed by different railroad companies in reporting breakage of rail, no uniform method was followed by different railroads in common, at least, in keeping record of rails in the track and the service given by rails. Railroads would report they had a rail in the track so many years. Such statements were valueless unless we knew how much traffic the rail had carried. Going back to the beginning of the history of the rail, we had no record of what part of the ingot the rail was taken from, we had no record as to what kind of a drop test had been made at the mills, and going back to the mills, when we found that some roads had a record of the drop test, then it developed that the drop testing machines themselves at the various mills varied so much in their construction that no accurate comparisons could be secured; so the result of our work has been, first, to adopt a series of forms on which to make reports of the records of rails from the very beginning and a uniform drop testing machine to be used at all mills. The drop testing machine has been described in detail in Bulletin 102, and has been voted on affirmatively by the Association. Nevertheless, the Committee bring it before you for reaffirmation, so that it may appear in the Manual. The blanks have also heretofore been presented by letter-ballot to the members of the Association, and have been approved, and these are brought before the Association for reaffirmation, and for placing in the Manual, so that the work of this Committee is all summarized and brought to a focus in Bulletin 106 under the head of conclusions, and these conclusions, as said before, many of them, have already been acted upon and we want a reaffirmation of them in order that they may appear in the Manual.

The President:—The Secretary will read the conclusions, and the chair will rule that in the absence of objections the conclusions will stand approved.

The Secretary:—"(1) That the complete set of rail statistic blanks, previously described and approved by letter-ballot, be used by the members of the Association for reporting and compiling information relative to rail failures and rail service.

"(2) That Form 2004-A, Summary of Steel Rail Failures for Six Months, Compared with the Same Period of Previous Year; Form 2004-D, Position in Ingot of Steel Rails Which Failed, and Form 2005-D, Record

of Comparative Wear of Special Rail, be adopted by the Association as approved forms for receiving statistics for the quantitative study of rail failures.

"(3) That the members of the Association furnish the Rail Committee with reports of studies of individual rail failures or rail service, from time to time, as soon as such studies have been made.

"(4) That Form M. W. 2003-A, heretofore submitted, be adopted as a standard form of the Association for receiving reports of the Chemical Analysis and Physical Tests of Individual Rails.

"(5) That a complete report of the study of an individual rail should consist of—

"(a) Copy of the Track Foreman's report on Form M. W. 2002-A, after being checked by an engineer.

"(b) Results of Chemical Analysis and Physical Test on Form M. W. 2003-A.

"(c) Photographs of the defect or fracture and micro-photographs of the interior structure.

"(d) A complete written analysis or deduction from the study of the above information."

Mr. C. E. Lindsay (New York Central & Hudson River Railroad):—We have in use on the New York Central Lines the Track Foreman's report Form M. W. 2002-A, and in practice we found it would be desirable to have the gage side of the rail indicated in some way, so that the defect in the rail could be referred to in its relation to the gage side. In some cases you cannot tell which is the gage side of the rail, from the picture or from the description in the report.

Mr. Churchill:—The Committee will take note of that and see if it can be introduced later on.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I wish to refer to paragraph (d) in conclusion 5, as to what constitutes a complete report. As I understand it, the different railroads are asked to transmit to the Committee interesting features of cases of rail failure. It is not within the power of a good many railroads to furnish the information that is called for here. For instance, there are quite a number of roads that do not maintain a laboratory for the purpose of making chemical analyses, nor have they the facilities or money to spare for the purpose of having photographs made of broken rails, etc. Am I to understand that the Committee does not want any report except those that are complete as defined in this conclusion?

Mr. Churchill:—The Committee desires that reports be made as fully as the conclusions specify, but where railroads are not equipped to furnish the report in such detail, they should say so. We want all the available information that can be furnished, and desire to have it as complete as possible to cover all questions that may arise.

Mr. McDonald:—The conclusion as it stands throws cold water on many lines. The information which the Committee will receive will probably be confined to those lines having sufficient organization to

supply the information described, unless you modify that conclusion in some way.

Mr. Churchill:—While it is desirable that all that information be given, the report should be as complete as possible from every road as far as that road is able to furnish the information. When the foremen's report is complete and the record of the rail is furnished, the Committee has very valuable information. If the Association wishes, our conclusion can be modified. We do not believe that any roads which have not the facilities for supplying all the detailed information will be deterred from giving such information as they may have.

Mr. W. C. Cushing (Pennsylvania Lines):—I might offer a word or two on that subject, which will make the intention of the conclusion a little clearer to Mr. McDonald. You will notice it says in No. 5 that this is a study of an *individual* rail, and it refers only to the study of the individual rail. If any company has any special information to give about any particular rail that it has studied, we recommend that it be furnished the Committee in that form. It has nothing to do with the filling out of those blanks which were sent around to the various members of the Association some time ago for general information as to the number of different kinds of rail failures. It does not apply to that at all. There are two kinds of rail studies to be made, one being the study of the *quantitative* number of failures of the group under the classification given in the track foreman's blank, and the other a study of *individual* pieces or lots of rail, which have failed. If a rail has failed under peculiar circumstances (because of a wreck possibly), a pretty thorough investigation of that rail is usually made, and this recommendation of the Committee outlines the manner in which the report should be made. The Committee already has had one or two such instances reported to it, and if they are printed in a Bulletin at some time in the future, it will be of much value to our members. A complete study of the rail cannot be made without all that information, such as chemical analysis, tensile strength, microscopic examination, etc. Nobody is asked to furnish it who cannot do it, but we feel there are many members who can make these studies from time to time, and the Committee should have the benefit of them.

The Secretary:—"(6) That the forms described above and approved by your Association by letter-ballot, also form 2003-A, be added to the Manual of Recommended Practice.

"(7) That the specifications and plan for Drop Testing Machine, heretofore submitted to the Association by letter-ballot, be adopted as standard.

"(8) That the specifications and plan for Drop Testing Machine be added to the Manual of Recommended Practice.

"(9) That the specifications for Bessemer Steel Rail, as presented in the Manual of Recommended Practice, be allowed to remain in the Manual as now printed.

"(10) That the following note be added to the specifications in the Manual: 'The Committee on Rail has under consideration the matter of revised specifications.'"

Mr. Churchill:—On behalf of the Committee, I move the adoption of the conclusions as read.

(Motion carried.)

The President:—Before excusing the Committee, the chairman of the Committee has a statement to make.

Mr. Churchill:—The work of the Committee has advanced to the extent of compiling, under sub-committee C, a statement of reports of breakage of rails for six months from a number of roads, and a compilation of this report, which is rather voluminous, is just completed for the six months ending October 31, 1908. This the Committee desires especially to be in as early a Bulletin as possible and to be made a part of the records of the Association.

Likewise, sub-committee A for this year made a number of tests at Sparrows Point Mill in the presence of the full Committee and in the presence of the manufacturers' committee, of a number of rails of different sections, including A sections and B sections of the new form, as well as the A. S. C. E. sections, and that compilation is about completed. That also will be given to the Association for publication in one of the early Bulletins and have general record in the Association's Proceedings.

Finally, sub-committee A, who have charge of testing joints as a whole, are following that up—it took quite a long time to get from the different railroads samples of joints. They have all gone forward to the Watertown Arsenal, and tests on joints are now in progress under the auspices of the Government at the Watertown Arsenal, overlooked by two committees—the Committee representing this Association and the Committee of the American Society for Testing Materials.

The President:—The Committee will be relieved with the thanks of the Association.

REPORT OF COMMITTEE NO. V—ON TRACK.

(Bulletin 108.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Track presents herewith its report for the year 1908.

The Committee has held four meetings during the year, in addition to meetings of sub-committees. The meetings were held in Chicago and New York and were attended by the following members: L. S. Rose, Chairman; C. E. Knickerbocker, Vice-Chairman; Garrett Davis, T. H. Hickey, J. B. Jenkins, C. E. Lindsay, S. S. Roberts, John C. Sesser, F. A. Smith, W. D. Wheeler and A. A. Wirth.

At a meeting held on May 20th the following sub-committees were appointed:

A—To revise the frog table submitted in 1908 and to extend the table to make it more nearly universal and to present a definite recommendation for the length of switch for each frog: F. A. Smith, Chairman; S. S. Roberts.

B—To prepare specifications for switch points to be used on Class A track: W. D. Wheeler, Chairman; Garrett Davis, E. C. Blundell.

C—To prepare specifications for standard spring frogs for Class A track: C. B. Hoyt, Chairman; R. D. Starbuck, T. H. Hickey.

D—To prepare specifications for switchstands: L. S. Rose, Chairman; John C. Sesser.

E—To confer with American Railway Master Mechanics' Association on the subject of widening of gage on curves, and to present report on throat clearance and guard rail clearance: L. S. Rose, Chairman; C. E. Knickerbocker, C. E. Lindsay.

F—To adapt formulas and tables on spirals for publication in the Manual: J. B. Jenkins, Chairman; to confer with Prof. Wm. G. Raymond.

The following outline of work was given your Committee by the Board of Direction:

(*1*) *Review and revise the Committee's report presented at the Ninth Annual Convention, covering the following subjects:*

(*a*) *Report on the subject of turnouts and turnout material, including the best types of switchstands, switchpoints, frogs, guard rails and throat clearance, bearing in mind the possibility of an increase of the thickness of wheel flanges and the effect of worn tires and wheels upon the various parts of turnouts, frogs and crossings.*

The Committee presents in Appendix A its report on the foregoing subjects.

(*b*) *Report on facing point switches for high speeds with a continuous main line rail.*

Your Committee reaffirms its report of last year on the subject of facing point switches with main line rail (see Proceedings, Vol. 9, p. 388).

(*c*) *Confer with Committee on Signaling relative to switchstands.*

Your Committee reports progress on this subject, and requests further time.

(*2*) *Continue investigations in connection with a sub-committee of the American Railway Master Mechanics' Association upon the subject of widening the gage on curves and spacing of guard rails, as affected by the different lengths of engine wheel base, arrangement of flanged wheels and wheel wear.*

Your Committee has held conferences with joint committees of the American Railway Master Mechanics' and Master Car Builders' Associations during the year and as a result begs to recommend the following resolution:

"*Resolved, That the clear width of standard flangeway for all frogs and between main rails and guard rails be 1¼ inches, measured at the gage line, for all tracks of standard gage."

The attached drawing shows position of wheels with maximum and standard flanges with reference to 1⅞ in. throatway and for 1¾ in. throatway. The meeting with the Wheel Committee of the Master Mechanics' Association brought out the fact that some changes were necessary in the M. C. B. standard reference gage as used for mounting. The corrected gage is shown on the drawing.

Your Committee requests further time in which to prepare its report on widening of gage.

(*3*) *Report on whether wide gage, which is due to worn rail, should be corrected by closing in or replacing the rail.*

After careful consideration of the above subject, your Committee begs to report as follows:

Wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to or exceeds one-half (½) in., and should then be corrected by closing in.

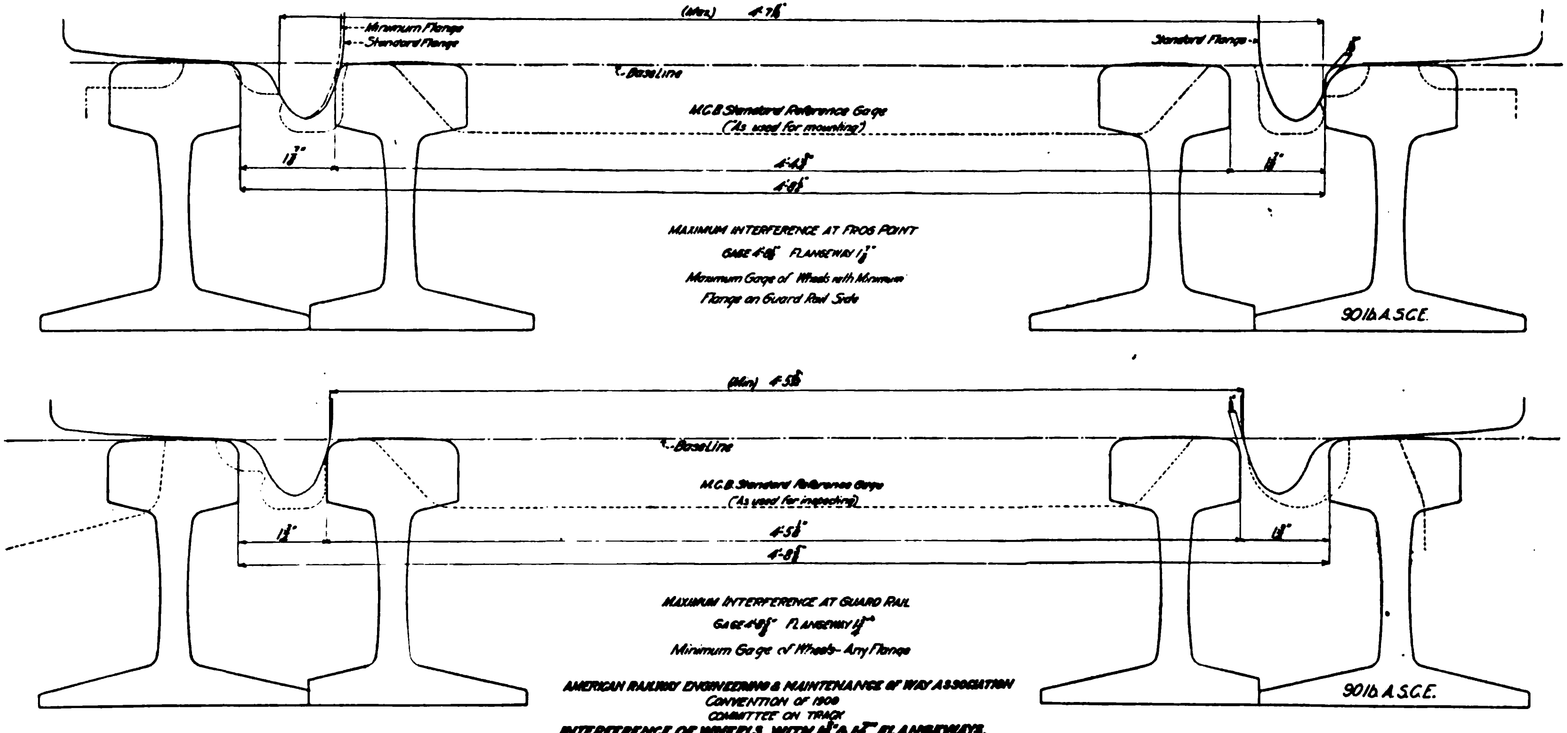
(*4*) *Report on the extent rail should be worn before it becomes unsafe.*

Your Committee is not in position to make a definite recommendation upon the extent rail should be worn before it becomes unsafe.

(*5*) *Consider revision of paragraph (3), under "Proper Method of Spiking," Manual, 1907, p. 64, and report recommendation as to extent gage on curves should be worn open before closing in is necessary.*

Your Committee has given careful consideration to the foregoing instruction, and recommends that the following paragraph be sub-

*Amend to read: "Resolved, That the clear width of standard flangeway for all frogs and between main rails and guard rails be 1¾ inches, measured at the gage line for all tracks of 4 feet 8½-inch gage."


Minimum Flange
Standard Flange
Standard Flange
Base Line
M.C.B. Standard Reference Gage
(As used for mounting)
MAXIMUM INTERFERENCE AT FROG POINT
Maximum Gage of Wheels with Minimum Flange on Guard Rail Side
90 lb. A.S.C.E.
Base Line
M.C.B. Standard Reference Gage
(As used for inspecting)
MAXIMUM INTERFERENCE AT GUARD RAIL
Minimum Gage of Wheels—Any Flange
90 lb. A.S.C.E.
AMERICAN RAILWAY ENGINEERING & MAINTENANCE OF WAY ASSOCIATION
CONVENTION OF 1909
COMMITTEE ON TRACK

stituted for the one now appearing on page 64 of the Manual of 1907 (the change consisting of the substitution of "one-half (½) in." for "three-eighths (⅜) in.)":

"(3) Within proper limit a slight variation of the gage from standard is not seriously objectionable, provided the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage track if the increase in gage has not amounted to more than one-half (½) in., provided such increase is uniform."

Under special instructions, dated May 4, your Committee has taken up the question of Easement Curve formula and has done considerable work upon it in order to get this formula in shape for the Manual. In order to settle upon lengths of spiral a circular was sent to the members and a tabulated list of replies is presented.

It was found necessary, in order to determine the Easement Curve formula, to have a definite definition for "Degree of Curve." The Committee presents tabulated replies to Circular No. 110, and a discussion upon this question by Prof. C. Frank Allen, Prof. Wm. G. Raymond, and others, which, we think, will be of benefit to the Association and may help solve this problem. (See Appendix B.)

CONCLUSIONS.

Your Committee recommends the adoption of the following conclusions:

(1) That the formula for the functions of the split switch proposed be approved as good practice.

(2) That the properties of the frogs and switch rails given in the accompanying tables be approved as good practice.

(3) That degree of curve be defined as the angle subtended by a 100 ft. chord.

*(4) That all curves be spiraled which would require 2-in. elevation for the highest possible speed.

(5) That wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to or exceeds one-half (½) in., and that it should then be corrected by closing in.

(6) That paragraph (3), page 64, of the Manual, under the heading of Maintenance of Line and Alinement, be withdrawn and the version submitted in the body of this report substituted.

Respectfully submitted,

L. S. Rose, Signal Engineer, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, O., *Chairman.*

C. E. Knickerbocker, Engineer Maintenance of Way, New York, Ontario & Western Railway, Middletown, N. Y., *Vice-Chairman.*

*Amend to read: "(4) That all curves be spiraled which would require 2-in. elevation for the highest permissible speed."

E. C. BLUNDELL, General Roadmaster, C., St. P., M. & O. Ry., Eau Claire, Wis.

GARRETT DAVIS, Superintendent, Chicago, Rock Island & Pacific Railway, Cedar Rapids, Ia.

T. H. HICKEY, Roadmaster, Michigan Central Railroad, St. Thomas, Ont.

C. B. HOYT, Superintendent Track, New York, Chicago & St. Louis Railroad, Bellevue, O.

J. B. JENKINS, Assistant Engineer, Baltimore & Ohio Railroad, Baltimore, Md.

C. E. LINDSAY, Division Engineer, New York Central & Hudson River Railroad, Albany, N. Y.

G. J. RAY, Chief Engineer, Delaware, Lackawanna & Western Railroad, Hoboken, N. J.

S. S. ROBERTS, Assistant Prof. Ry. Eng., Univ. of Illinois, Urbana, Ill.

R. O. ROTE, JR., Principal Assistant Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

JOHN C. SESSER, Chicago, Ill.

F. A. SMITH, Chicago, Ill.

R. D. STARBUCK, Assistant Chief Engineer, Michigan Central Railroad, Detroit, Mich.

R. A. VAN HOUTEN, Division Engineer, Lehigh Valley, Easton, Pa.

W. D. WHEELER, Chief Engineer, Minneapolis & St. Louis Railway, Minneapolis, Minn.

A. A. WIRTH, Engineer Maintenance of Way, Pennsylvania Lines, Pittsburg, Pa.

Committee.

Appendix A.

PROPERTIES OF THE SPLIT SWITCH.

In view of the instructions of the Board of Direction to revise the Frog and Switch Table submitted by the Track Committee to the convention of 1907, we consider it advisable to submit:

(1) Revised formulas for determining the properties of the modern split switch.

(2) A table of the properties of frogs and switch rails for use on roads using rail weighing 80 lbs. per yard or less.

(3) A similar table for roads using rail weighing more than 80 lbs. per yard.

Until all of the above points are definitely determined, we feel it would be of no avail to figure the leads and other functions of the entire turnout.

THE SPLIT SWITCH.

Given—

G = Gage of track.
N = Frog number.
F = Frog angle.
W = Length of wing rail.
S = Length of switch rail.
H = Heel distance.

Required—

a = Switch angle
L = Lead distance measured along center line of main track from point of switch to point of frog.
R = Radius of center line of lead curve.
D = Degree of lead curve.
$\overline{CE_1ED}$ = Arc of outer rail of lead curve.
$\overline{Z_1D_1}$ = Length of straight rail in lead.
Y = Perpendicular offset from any point on the curved lead rail to the main track rail.
X = Distance from foot of such offset to point of switch rail.

In the accompanying figure, A, Z, V, B and Z_1, D_1, P, represent points on the gage sides of the main track rails. C, E_1, E and D represent points on outer rail of lead curve.

G = Gage.
P = Theoretical point of frog.
D = Toe of frog.
$\overline{PD} = W$ = Length of wing rail.
$\angle Z_1PD = \angle Z_1PI = F$ = Frog angle
A = Point of switch rail.
C = Heel of switch rail.
$\overline{AC} = S$ = Length of switch rail.
Z = Foot of perpendicular from gage side of switch rail at heel upon gage side of main track rail.
$\overline{CZ} = H$ = Heel distance.
$CAZ = \angle UAB = a$ = Switch angle.
O = Center of lead curve.
R = Radius of lead curve.
D = Degree of lead curve.
$\overline{CD}$ = Long chord of lead curve.

CE_1ED = Arc of curved or outer rail of lead curve tangent to heel of switch rail at C and to toe of frog at D.

$\overline{OC} = \overline{OE_1} = \overline{OE} = \overline{OD} = (R + \frac{G}{2})$ = Radii of outer rail of lead curve.

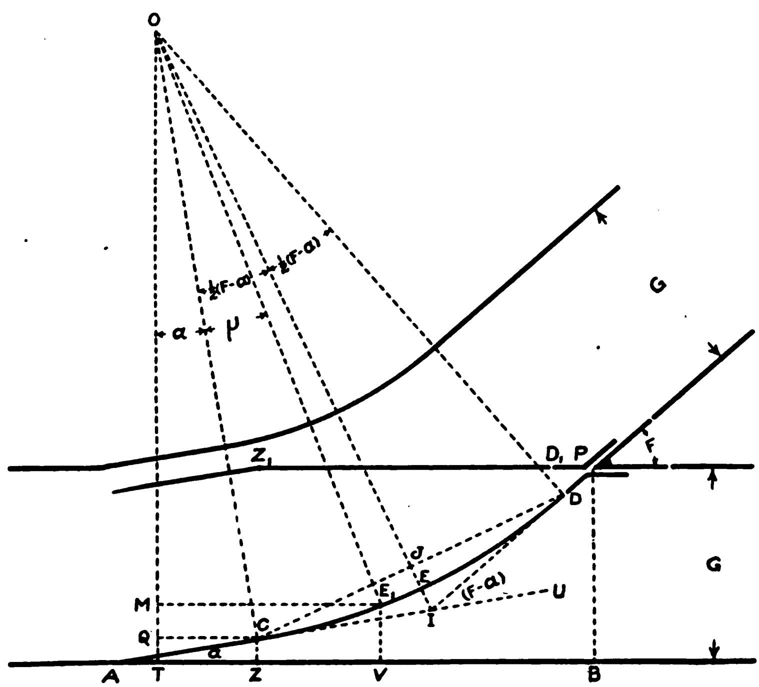
Extend $\overline{PD}$ and $\overline{AC}$ to intersect at I, then $\overline{DI} = \overline{CI}$ = Tangent distance of lead curve.

$\measuredangle DIU = \measuredangle DOC = (F - a)$ = Angle of intersection = Center angle of lead curve.

$\measuredangle DCI = \measuredangle DOI = \measuredangle IOC = \frac{1}{2}(F - a)$. $(\measuredangle DCI + \measuredangle CAZ) = \frac{1}{2}(F + a)$ = Angle of long chord $\overline{CD}$ with $\overline{AB}$.

B = Foot of perpendicular from point of frog upon gage side of opposite main track rail.

$\overline{AB}$ = Lead.



$$\text{Sin } \measuredangle CAZ = \frac{CZ}{AC} = \sin a = \frac{H}{S} \therefore a = \sin^{-1}\frac{H}{S} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

To correct for actual thickness of point of switch rail, deduct the thickness of the point from H before dividing by S.

The sum of the projections of $\overline{AC}$, $\overline{CD}$, and $\overline{DP}$ upon $\overline{PB}$ is equal to $\overline{PB}$.

$(\overline{AC} \cdot \sin \measuredangle CAZ) + [\overline{CD} \cdot \sin (\measuredangle DCI + \measuredangle CAZ)] + (\overline{DP} \cdot \measuredangle Z_1PD) = PB$

Substituting the values of the given quantities and solving for CD.

$$\overline{CD} = \frac{G - (W \cdot \sin F + S \cdot \sin a)}{\sin \frac{1}{2} (F + a)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The sum of the projections $\overline{AC}$, $\overline{CD}$, and $\overline{DP}$ upon $\overline{AB} = \overline{AB}$.

$\overline{AB} = (\overline{AC} \cdot \cos \measuredangle CAZ) + [\overline{CD} \cdot \cos (\measuredangle DCI + \measuredangle CAZ)] + (DP \cdot \cos \measuredangle Z_1PD)$

$L = S \cdot \cos a + CD \cdot \cos \frac{1}{2} (F + a) + W \cdot \cos F \ldots\ldots\ldots\ldots\ldots\ldots (3)$

Substituting in (3) the value for $\overline{CD}$ given in (2) and simplifying,

$$L = (S - W) \frac{\sin \frac{1}{2} (F - a)}{\sin \frac{1}{2} (F + a)} + G \cdot \cot \tfrac{1}{2} (F + a) \ldots\ldots\ldots\ldots (4)$$

(a) To correct for the actual thickness of the point of switch rail, deduct the thickness of the point from G before solving (4). (b) To correct for the actual thickness of the point of frog. After solving (4), increase L by the product obtained by multiplying the thickness of the frog point (expressed in decimals of a foot) by the frog number.

$$\overline{OD} = \frac{\overline{JD}}{\sin \measuredangle DOJ} = \frac{CD}{2 \cdot \sin \frac{1}{2} (F - a)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Substituting for $\overline{CD}$ in (5) the value given in (2), and solving for R.

$$R = \frac{G - H - W \cdot \sin F}{2 \cdot \sin \frac{1}{2} (F - a) \cdot \sin \frac{1}{2} (F + a)} - \frac{G}{2} \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

or the value of R may be expressed as follows:

$$R = \frac{G - H - W \cdot \sin F}{\cos a - \cos F} - \frac{G}{2} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$D = 2 \cdot \sin^{-1} \frac{50}{R} \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$\overline{CE_1},\ \overline{ED} = \frac{2 \cdot \pi \cdot \left(R + \frac{G}{2}\right) \cdot (F - a)}{360} = 0.0175 \cdot \left(R + \frac{G}{2}\right) \cdot (F - a) \ldots (9)$$

In (9), $(F - a)$ is expressed in degrees and decimals of a degree.

$Z_1D_1 = L - (W + S) \ldots\ldots\ldots\ldots\ldots\ldots (10)$

Let E_1 be any point on the gage side of the outer rail of the lead curve. Draw the radius $\overline{OE}$. Drop a perpendicular from O upon the gage side of the main track rail at T. From O draw the radius $\overline{OC}$ perpendicular to the switch rail at its heel. $\measuredangle COT = a$. From E_1 let fall a perpendicular upon the gage side of the main track rail at V and upon $\overline{OT}$ at M. Let fall a perpendicular from C upon the gage side of the main track rail at Z and upon $\overline{OT}$ at Q. Let $\measuredangle E_1OC = \mu$ and let A = point of switch rail.

$Y = \overline{E_1V} = \overline{MT} = (\overline{OQ} - \overline{OM} + \overline{QT}) = \overline{OQ} - \overline{OM} + \overline{CZ}$

$$Y = \left[H + \left(R + \frac{G}{2}\right) \cdot \cos a\right] - \left(R + \frac{G}{2}\right) \cdot \cos (\mu + a) \ldots\ldots\ldots\ldots (11)$$

$X = (\overline{AT} + \overline{TV}) = (\overline{AZ} - \overline{TZ}) + \overline{TV} = (\overline{AZ} - \overline{QC} + \overline{ME_1}$

$$X = \left[S - \left(R + \frac{G}{2}\right) \cdot \sin a\right] + \left(R + \frac{G}{2}\right) \cdot \sin (\mu + a) \ldots\ldots\ldots\ldots (12)$$

SUMMARY.

$$a = sin^{-1} \cdot \frac{H}{S} \qquad (1)$$

$$L = (S - W)\frac{sin\ \tfrac{1}{2}\ (F - a)}{sin\ \tfrac{1}{2}\ (F + a)} + G \cdot cot\ \tfrac{1}{2}\ (F + a) \qquad (4)$$

$$R = \frac{G - H - W \cdot sin\ F}{2 \cdot sin\ \tfrac{1}{2}\ (F - a) \cdot sin\ \tfrac{1}{2}\ (F + a)} - \frac{G}{2} \qquad (6)$$

$$R = \frac{G - H - W \cdot sin\ F}{cos\ a - cos\ F} - \frac{G}{2} \qquad (7)$$

$$D = 2 \cdot sin^{-1}\frac{50}{R} \qquad (8)$$

$$\overline{CE_1ED} = 0.017453 \cdot \left(R + \frac{G}{2}\right) \cdot (F - a) \qquad (9)$$

$$\overline{Z_1D_1} = L\ (W + S) \qquad (10)$$

$$Y = \left[H + \left(R + \frac{G}{2}\right) \cdot cos\ a\right] - \left(R + \frac{G}{2}\right) \cdot cos\ (\mu + a) \qquad (11)$$

$$X = \left[S - \left(R + \frac{G}{2}\right) \cdot sin\ a\right] + \left(R + \frac{G}{2}\right) \cdot sin\ (\mu + a) \qquad (12)$$

To correct (1) and (4) for the actual thickness of point of switch rail, deduct the thickness of the point from H and G before solving for a and L. To correct (4) for the actual thickness of the frog point: After solving (4), increase L by the product of N.t, where N = frog number and t = actual thickness of frog point expressed in decimals of a foot. In (9), $(F - a)$ is expressed in degrees and decimals of a degree. In (11) and (12) it is recommended that the value of Y and X be obtained for at least three values of μ, namely, $\mu = \tfrac{1}{4}\ (F - a)$, $\mu = \tfrac{1}{2}\ F - a)$, $\mu\ \tfrac{3}{4}\ (F - a)$.

In the tables submitted, the dimensions of the frogs are so computed that—

(1) A 36-in. angle-bar splice may be applied, without clipping, to a frog made of 80-lb. rail.

(2) A 36-in. angle-bar splice may be applied, without clipping, to a frog made of 110-lb. rail.

In both tables the frogs from No. 9 to No. 15, inclusive, have been made of sufficient length from point to toe to permit of being made spring frogs, if so desired.

The switch angles are chosen arbitrarily, after some trial, and are kept as small as seems consistent and of as nearly the same angle for the same number of frog as practicable; the Committee having found from comparison of the results of various computations that for any given frog, whether the heel distance remains constant and the switch angle varies or the switch angle remains constant and the heel distance varies, the change in the degree of the lead curve is *practically* the same for equal changes in the length of the switch rail. So that, considering the switch angle constant and knowing the length of the

lead and radius of the lead curve for any given length of switch rail and number of frog, the length of lead and radius of lead curve for any other length of switch rail with the same frog may be much more easily computed than when different switch angles are used with the same number of frog.

Thus from equations (4) and (7),

$$L_1 = L - \left[(S - S_1) \frac{Sin \frac{1}{2} (F - a)}{Sin \frac{1}{2} (F + a)} \right]$$

$$R_1 = R + \frac{H - H_1}{Cos\, a - Cos\, F}$$

Where L, S, R and H are the length of lead, length of switch rail, radius and heel distance of a given frog and switch rail and L_1, S_1, R_1 and H_1 are the corresponding functions of the turnout for the same frog with any other length of switch rail as S_1.

By keeping F and a constant for the same frog it may be seen by inspection of the formulas submitted that a series of constants may be worked out, so that, knowing the functions of the turnout for a given frog and length of switch rail, the functions of the turnout for the same frog and any other length of switch rail may be obtained by one or two simple processes of calculation for each function. This would also be true if the length of the switch rail remained constant and the length of the wing rail varied or if both the length of the switch rail and the wing rail varied.

It is found that with the splice and rail sections considered, a prohibitively great heel distance would have to be used to permit the application of the splice to the switch rail without clipping; for this and other reasons, the heel distances given in the tables have been selected.

110-LB. RAIL AND LESS, BUT GREATER THAN 80-LB. 36-IN. ANGLE BAR SPLICE.

Properties of Frog.								Properties of Switch.			
1	2	3	4	5	6	7	8	9	10	11	12
N=Number of Frog.	F=Frog Angle.	W=Length Point to Toe.	K=Length Point to Heel.	Total Length.	Spread at Toe.	Spread at Heel.	Thickness of Point.	S=Length of Switch Rail.	Thickness of Switch Rail at Toe.	Heel Distance.	A=Switch Angle.
4	14° 15′00″	3′02″	5′04″	8′06″	0.79′	1.32′	0¼″	12′	0¼″	06¼	2° 23′17″
5	11° 25′16″	3′07″	6′05″	10′00″	0.71′	1.28′	0¼″	12′	0¼″	06¼	2° 23′17″
6	9° 31′37″	4′00″	7′00″	11′00″	0.66′	1.16′	0¼″	12′	0¼″	06¼	2° 23′17″
7	8° 10′17″	4′05″	8′01″	12′06″	0.63′	1.15′	0¼″	15′	0¼″	06¼	1° 54′37″
8	7° 09′10″	4′09″	8′09″	13′06″	0.59′	1.09′	0¼″	18′	0¼″	06¼	1° 35′30″
9	6° 21′35″	6′00″	10′00″	16′00″	0.67′	1.11′	0¼″	18′	0¼″	06¼	1° 35′30″
9½	6° 01′31″	6′00″	10′00″	16′00″	0.63′	1.05′	0¼″	18′	0¼″	06¼	1° 35′30″
10	5° 43′29″	6′00″	10′06″	16′06″	0.60′	1.05′	0¼″	21′	0¼″	06¼	1° 21′52″
11	5° 12′19″	6′00″	11′06″	17′06″	0.54′	1.05′	0¼″	21′	0¼″	06¼	1° 21′52″
12	4° 46′19″	6′05″	12′01″	18′06″	0.53′	1.01′	0¼″	21′	0¼″	06¼	1° 21′52″
15	3° 49′06″	7′08″	14′10″	22′06″	0.51′	0.99′	0¼″	24′	0¼″	06¼	1° 11′37″
18	3° 10′56″	8′10″	17′08″	26′06″	0.49′	0.98′	0¼″	24′	0¼″	06¼	1° 11′37″
20	2° 51′51″	9′08″	19′04″	29′00″	0.48′	0.97′	0¼″	30′	0¼″	06¼	0° 57′18″
24	2° 23′11″	11′04″	23′02″	34′06″	0.47′	0.97′	0¼″	30′	0¼″	06¼	0° 57′18″

80-LB. RAIL AND LESS. 36-IN. ANGLE BAR SPLICE.

Properties of Frog.								Properties of Switch.			
1	2	3	4	5	6	7	8	9	10	11	12
N=Number of Frog.	F=Frog Angle.	W=Length Point to Toe.	K=Length Point to Heel.	Total Length.	Spread at Toe.	Spread at Heel.	Thickness of Point.	S=Length of Switch Rail.	Thickness of Switch Rail at Toe.	Heel Distance.	A=Switch Angle.
4	14° 15′00″	3′00″	5′00″	8′00″	0.74′	1.24′	0¼″	10′	0¼″	05″	2° 16′06″
5	11° 25′16″	3′04″	5′08″	9′00″	0.66′	1.13′	0¼″	10′	0¼″	05″	2° 16′06″
6	9° 31′37″	3′08″	6′04″	10′00″	0.61′	1.05′	0¼″	10′	0¼″	05″	2° 16′06″
7	8° 10′17″	4′01″	7′05″	11′06″	0.58′	1.06′	0¼″	12′	0¼″	05″	1° 53′24″
8	7° 09′10″	4′05″	8′01″	12′06″	0.55′	1.01′	0¼″	15′	0¼″	05″	1° 30′30″
9	6° 21′35″	6′00″	9′00″	15′00″	0.67′	1.00′	0¼″	15′	0¼″	05″	1° 30′30″
9½	6° 01′31″	6′00″	9′00″	15′00″	0.63′	0.95′	0¼″	16.5′	0¼″	05″	1° 22′29″
10	5° 43′29″	6′00″	9′06″	15′06″	0.60′	0.95′	0¼″	16.5′	0¼″	05″	1° 22′29″
11	5° 12′19″	6′00″	10′06″	16′06″	0.54′	0.95′	0¼″	16.5′	0¼″	05″	1° 22′29″
12	4° 46′19″	6′00″	11′00″	17′00″	0.50′	0.92′	0¼″	16.5′	0¼″	05″	1° 22′29″
15	3° 49′06″	7′00″	13′06″	20′06″	0.47′	0.90′	0¼″	20′	0¼″	05″	1° 08′02″
18	3° 10′56″	8′06″	15′06″	24′00″	0.47′	0.86′	0¼″	20′	0¼″	05″	1° 08′02″
20	2° 51′51″	8′10″	17′02″	26′00″	0.44′	0.86′	0¼″	30′	0¼″	05″	0° 45′21″
24	2° 23′11″	10′07″	20′05″	31′00″	0.44′	0.85′	0¼″	30′	0¼″	05″	0° 45′21″

SPECIFICATIONS FOR FROGS AND SWITCHES.

GENERAL.

The Company will furnish the Manufacturer one copy of the specifications and working drawings.

The working drawings will show the rail sections, splice drilling, angle alinement and general dimensions.

All drawings are a part of the specifications, and must be so considered. Where figures are given, they are intended to be followed in preference to measurement by scale. Anything which is not shown on the drawings, but which is mentioned in the specifications, or vice versa, or anything not expressly set forth in either, but which is reasonably implied, shall be furnished. Should anything be omitted from the drawings or specifications which is necessary for a clear understanding of the work, or should any error appear either in the drawings or specifications affecting the work, it shall be the duty of the Manufacturer to notify the Company.

MATERIALS.

Rail. 1. The rail shall be first quality, open-hearth steel, manufactured in accordance with the specifications of the American Railway Engineering and Maintenance of Way Association. At its option, the rail may be furnished by the Company.

Filling. 2. The filling shall be cast or rolled steel, or rolled iron.

Bolts and Rivets. 3. Bolt and rivets shall be made from a good quality of milled steel with ultimate tensile strength of 50,000 to 54,000 lbs. per sq. in., or be made of refined B. B. iron. Bolt iron should be true and round and conform to the diameter specified.

Raising Blocks. 4. Raising blocks shall be made from forged or rolled steel.

Plates. 5. Plates shall be made from rolled steel or rolled iron.

Braces. 6. Braces shall be made from rolled steel or malleable iron.

Reinforcing Bars. 7. Reinforcing bars shall be made of wrought-iron or soft steel.

Springs. 8. Springs shall be made of the best quality of spring steel.

Spring Covers. 9. Spring covers shall be made from malleable iron or steel.

Switch Lugs. 10. Switch lugs shall be made of good quality open-hearth steel or wrought-iron.

Switch Rods. 11. Switch rods shall be made from good quality wrought-iron.

Foot Guards. 12. Foot guards shall be made from rolled steel, except where solid, when they shall be made of cast or rolled steel or rolled iron.

Workmanship. 13. Workmanship shall be first-class.

All holes for bolts and rivets except in castings shall be drilled and all burrs removed.

All bends shall be made accurately and with care, so as not to injure the material. They shall be in arcs of circles and not angles. It is desired that rails be bent cold. If heating of rail is resorted to, it shall be done in a manner so as not to injure it. Welding in any part of the frog and switch work is prohibited. Planing shall be

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Note.—The Committee is not a unit upon the above specifications for Frogs and Switches, and they are submitted as a progress report.

true, and all abutting surfaces shall fit closely. Ends of rails shall be cut at right angles to the axis of the rail, except where shown on the plans. All burrs shall be removed. The surface and line shall be true. No paint, tar or other covering shall be used.

INSPECTION.

Inspection. Material and workmanship shall at all times be subject to inspection by a duly authorized representative of the Company, who shall examine the material before it is worked in the shop and shall have supervision over the work during progress; and shall also inspect the finished product, with power to reject materials and workmanship found to be unsatisfactory. He shall have free access to the shops and mills at any and all times during the progress of the work.

The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery or during the progress of the work, and such material if furnished by the Manufacturer shall be replaced by him at his own expense.

All facilities, labor and tools necessary for the inspection shall be furnished at the expense of the Manufacturer.

Where the Manufacturer furnishes the rails, he shall supply the Company with a certificate of inspection made by some competent person acceptable to the Company.

SPRING RAIL FROGS.

Point Rail. Point rail shall be round on top and sides at working point. Frog number, weight, date made and name of maker must be stamped on the top surface near the flare end of fixed wing rail.

Movable Wing Rail. Movable wing rail shall be bent so as to fit closely against the point rail from the point to where it is five and one-half (5½) in. from gage line of main track rail.

Reinforcing Bars. Reinforcing bars shall be three-quarters (¾) in. in thickness and of sufficient width to properly fill the space between the bottom flange and head of rail, and made to fit the fishing angles. It shall be fastened to the movable wing rail with five-eighths (⅝) in. rivets or bolts.

End of reinforcing bar at the toe end of frog shall not be less than forty-five and one-half (45½) in. ahead of working point.

The hold-downs may be a part of the reinforcing bar or a separate attachment.

Rail Braces. Rail braces or stops shall be provided, so placed as to limit the opening to one and seven-eighths (1⅞) in. between the movable wing rail and the working point. Where rail braces are shown, they must be five-sixteenths (5/16) in. in thickness, and must be riveted to the plates with rivets at least one-half (½) in. in diameter.

Springs. All springs shall be double springs, the outside diameter of outside spring being not less than two and one-half (2½) in., and free length of both springs five and one-half (5½) in.; outside spring shall be three-eighths (⅜) in. thick, with seven coils, and inside one-quarter (¼) in. thick and ten coils. Each spring shall have its free length measured when standing on end on a flat surface, it shall then

be placed in a testing machine, closed up solid, and held in this position for at least thirty seconds, after which its free length measured at the same point on the coil as before shall not differ by more than one-sixteenth ($\frac{1}{16}$) in. from the measurement taken before the test.

Fillers. Fillers shall be solid and continuous and shall fit snugly between head and base of rail; flangeway shall not be less than one and three-quarters ($1\frac{3}{4}$) in. in depth measured below the top of rail.

The front end of the filler shall be one-half ($\frac{1}{2}$) in. ahead of the working point, the filler to fit the sectional rail and be notched at the working point forming a shoulder for the frog point. The fillers shall be grooved or cut out to fit over the rivet heads, and cut to fit the web at the bend.

Holes. All holes drilled before assembling must be made one-sixteenth ($\frac{1}{16}$) in. less in diameter than the bolts to be used. After the parts are assembled, the holes shall be reamed so that they are straight and true and are of such size as to give the bolts a driving fit.

A rising block shall be placed at the heel of the frog. The top of the block shall be flush with the top of rail from a point where the heads of the rail are one-half ($\frac{1}{2}$) in. apart to where the distance between the center lines of the webs is five and one-half ($5\frac{1}{2}$) in., extending a further distance of four and one-half ($4\frac{1}{2}$) in., making a gradual slope with the end three-eighths ($\frac{3}{8}$) in. below the top of rail head. The block must rest on flanges of the point rails and not be less than one (1) in. thick at any point. If an inverted rail is used for this purpose, the space between the webs, head and base of rail shall be completely filled by cast-iron filling blocks.

Bolts. U. S. standard heads and nuts shall be provided for all bolts. The threads shall be accurately cut, and nuts shall have a wrench-tight fit. Each bolt shall be provided with an efficient headlock, preventing the bolt from turning, and a nutlock large enough to give full bearing for a nut, a one-quarter ($\frac{1}{4}$) in. cotter to be placed outside of nut. Beveled washers will be used wherever necessary to give head and nut a good square bearing. Bolts shall be long enough to allow the nuts to be brought out from under head of rail, with a suitable washer not less than one-half ($\frac{1}{2}$) in. thick, so that nuts may be readily tightened with an ordinary wrench.

SWITCHES.

Switch Points. Switch points shall fit stock rail throughout the planing. Ends of switch rails must be cut at right angles to axis of rail, and all burrs removed. The planing must be made so that the point is three-eighths ($\frac{3}{8}$) in. below the top of stock rail. The center line of holes for lug bolts must be on a line one-quarter ($\frac{1}{4}$) in. below the center line of web.

Bolts. Turned bolts shall be used connecting lugs and switch rods and at switchstand connections. These bolts shall be provided with standard threads and nuts. All bolts shall be provided with cotters. All holes for bolts shall be drilled $\frac{1}{16}$-in. larger than diameter of bolts.

Appendix B.

THE USE OF SPIRALS AND DEFINITION OF DEGREE OF CURVE.

Your Committee on Track issued the following circular to the members of the Association:

(*Circular 102.*)

1 What is the minimum degree of curve on which you use spirals for speed of 30 miles per hour; 40 miles per hour; 50 miles per hour; 60 miles per hour; 70 miles per hour; 80 miles per hour?

2 What do you consider the minimum offset between tangent and circu'ar curve which it is practicable to use for a spiral?

(The object of the above inquiries is to establish either (a) a minimum length for spirals, or (b) a minimum offset; no easement curve to be used on curves where conditions would require either a shorter spiral or a smaller offset than the minimum to be determined upon.)

3 What do you consider the safe minimum distance for which elevation should be run out for low speeds? (Give distance in feet per inch of elevation.)

4 What do you consider the most satisfactory distance for which elevation should be run out for low speeds?

5 What do you consider the most satisfactory distance for which e'evation should be run out for low speeds?

6 What do you consider the most satisfactory distance for speeds of 40 miles per hour; 50 miles per hour; 60 miles per hour; 70 miles per hour; 80 miles per hour?

7 In new location, are you governed in the choice of spirals mainly by topography; speed; degree of curve; within what limits?

8 In new location, do you endeavor to make your spirals as much a part of the permanent alinement as the tangents and circular curves?

9 From your experience or observation, what per cent. can the speed be exceeded without discomfort over the calculated speed to which the rai's are elevated?

The value of the answers to this circular was unfortunately impaired by a misprint in the second question in the circular, making "offset" read "of feet," and by a very general misinterpretation of the third and sixth questions.

In spite of these deficiencies, the replies are more complete than was hoped for, and while they show a wide variation in practice, this variation was expected. The results of the inquiry are of great interest and value.

MINIMUM CURVE SPIRALED FOR VARIOUS SPEEDS AND MINIMUM PRACTICABLE OFFSET AND LENGTH.

NAME OF ROAD.	NAME AND POSITION OF MEMBER.	MINIMUM CURVE SPIRALED. Speed in Miles per Hour. 30	40	50	60	70	80	Minim'm Offset.	Minim'm Length.
A. T. & S. F. Ry.	J. M. Meade, Engineer Eastern Grand Division	2	2	0–30	0–30				16.7
A. T. & S. F. Ry.	C. A. Morse, Chief Engineer	2	1–30	1	0–30	0–30	0–30	0.01	30
Boston & Maine	J. P. Snow, Bridge Engineer	4	3	2	1–30	1	1	0.50	
B. & O. R. R.	H. R. Talcott, Engineer of Surveys	1	1	0–30	0–30	0–30		0.01	
B. & O. R. R.	A. W. Thompson, Chief Engineer Maintenance of Way	1	1	0–30	0–30	0–30		0.01	
B. & O. R. R.	G. D. Brooke, Assistant Engineer	1	1	0–30	0–30	0–30	0–30		
B. & O. R. R.	J. B. Jenkins, Assistant Engineer ... Preference	5	2	1	0–40	0–25	0–15	0.04	100
	B. & O. Practice	1	1	0–30	0–30	0–30	0–30		
B. & O. R. R.	E. G. Lane, Engineer Maintenance of Way	3	2	1	0–30				50
B. & S. R. R.	H. C. Landon, Engineer Maintenance of Way	3	2	1	1	0–30	0–30		
C. B. & Q. R. R.	T. E. Calvert, Chief Engineer	1–30	1–30	1–30	1–30	1–30	1–30		
C. B. & Q. R. R.	Geo. H. Bremner, Engineer Maintenance of Way	1–30	1–30	1–30	1–30	1–30	1–30		
C. C. C. & St. L.	A. L. Kuehn, Engineer Track and Roadway	3	1–30	1	0–45	0–30	0–20	0.08	
C. C. C. & St. L.	R. Ferriday, Engineer Maintenance of Way, P. & E. Ry.	5–03	2–50	1–49	1–16	1–00	1–00	0.30	
C. I. & L. Ry.	A. S. Kent, Division Engineer	2	2	1–30	1	1	1		100
C. P. R.	F. P. Gutelius, Assistant Chief Engineer	2	2	2	1				100
C. R. I. & P. Ry.	A. K. Shurtleff, Office Engineer	2	2	2					
C. R. I. & P. Ry.	John C. Beye, Locating Engineer	2	2	2	2				30
C. R. I. & P. Ry.	Garrett Davis, Superintendent		3	2	2	1	1		100
Cornell University	C. L. Crandall, Professor of Railroad Engineering	2			1–30	1	0–45	0.15	
D. L. & W. R. R.	G. J. Ray, Chief Engineer		1–30	1	1				60
E. P. & S. W. Ry.	J. L. Campbell, Engineer Maintenance of Way	1	1	1	1	0–30	0–30		90
Erie R. R.	W. M. Dawley, Assistant Engineer								
G. R. & I. R. R.	F. J. Stimson, Engineer Maintenance of Way	3	3	2	1–30				175
Grand Trunk	H. G. Kelley, Chief Engineer	1	1	1	1	0–30	0–30		60
I. C. R. R.	H. R. Safford, Chief Engineer Maintenance of Way	2	2	1–30	1	0–30	0–30		
I. C. R. R.	C. W. Pifer, Roadmaster	2	2	2	1	1	1		
L. S. & M. S. Ry.	Willard Beahan	0–30	0–30	0–30	0–30	0–30	0–30		100
L. & A. R. R.	F. W. Green, General Superintendent		2–30	2–30				1.14	
L. I. R. R.	J. B. Austin, Jr., Engineer Maintenance of Way	3	2–45	2–30	2–15	2	2		150
L. & N. R. R.	J. F. Burns, Roadmaster	2	2	2	2				160
Lehigh Valley	E. B. Ashby, Chief Engineer	2	2	2	1	1	1		100
M. K. & T. Ry.	S. B. Fisher, Chief Engineer	1	1	1	1				40
N. C. & St. L. R. R.	Hunter McDonald, Chief Engineer	3	2	2	1	1	1		15
N. & W. R. R.	C. C. Wentworth, Principal Assistant Engineer	4	4	4					
N. Y. C. & H. R. R. R.	G. W. Kittredge, Chief Engineer	1	1	1	1	1	1	0.07	100
N. Y. C. & St. L. R. R.	A. J. Himes, Assistant Chief Engineer	2	1	1	1				
P. & L. E. R. R.	J. A. Atwood, Chief Engineer	2	1	0–30	0–30	0–30	0–30		50
P. & L. E. R. R.	Edwin F. Wendt, Assistant Engineer		0–30	0–30	0–30	0–30	0–30		
Penna. Lines West	W. C. Cushing, Chief Engineer Maintenance of Way	2	2	0–45	0–45	0–45	0–45		40
Penna. Lines West	R. Trimble, Chief Engineer Maintenance of Way	2	2	0–45	0–45	0–45	0–45		60
Penna. Lines West	Frank Rhea, Engineer Maintenance of Way	2–30	2	1–30	1–30	1	1		90
Philippine Railways	Wm. B. Poland, Vice-President and Chief Engineer	3	2	1	1	0–30	0–30		
S. L. & S. F. R. R.	C. D. Purdon, Consulting Engineer	2–30	2–30	2–30				0.10	
Seaboard Air Line	J. C. Nelson, Engineer Maintenance of Way	1	1	1	1	1	1		
Transcontinental	D. MacPherson, Assistant Chief Engineer	1	1	1					30
W. P. Ry.	V. G. Bogue, Vice-President and Chief Engineer	4	3	2	2	1	1	0.30	
	Highest	5–03	4	4	2–15	2	2	1.14	175
	Lowest	1	0–30	0–30	0–30	0–30	0–20	0.01	15
	Mean	2–13	1–48	1–24	1–01	0–47	0–48	0.23	75

LENGTH OF RUNOFF PER INCH OF ELEVATION FOR VARIOUS SPEEDS.

Name of Road.	Name and Position of Member.	Safe Run-off for Low Speed.	Most Satisfactory Runoff. Speed in Miles per Hour. Low.	40	50	60	70	80
A. T. & S. F. Ry.	J. M. Meade, Engineer Eastern Grand Division	30	45	60	60	60	60	60
A. T. & S. F. Ry.	C. A. Morse, Chief Engineer	25	33					
Boston & Maine	J. P. Snow, Bridge Engineer	30	50					
B. & O. R. R.	H. R. Talcott, Engineer of Surveys	25	40	45	50	60	70	80
B. & O. R. R.	A. W. Thompson, Chief Engineer Maintenance of Way	25	50	50	50	60	70	
B. & O. R. R.	G. D. Brooke, Assistant Engineer			40	50	60	70	80
B. & O. R. R.	J. B. Jenkins, Assistant Engineer	15	30	30	37.5	45	52.5	60
B. & O. R. R.	E. G. Lane, Engineer Maintenance of Way	25	50	60	80	120		
B. & S. R. R.	H. C. Landon, Engineer Maintenance of Way	15	30	30	40	60	100	100
C. B. & Q. R. R.	Geo. H. Bremner, Engineer Maintenance of Way	30	80	60	80	80	120	120
C. C. C. & St. L.	A. L. Kuehn, Engineer Track and Roadway	25	33	50	67	80	100	100
C. C. C. & St. L.	R. Ferriday, Engineer Maintenance of Way, P. & E. Ry.	10	30	40	50	60	70	80
C. I. & L. Ry.	A. S. Kent, Division Engineer	66		66	66	66		
C. P. R.	F. P. Gutelius, Assistant Chief Engineer	30	60	60	60	60		
C. R. I. & P. Ry.	A. K. Shurtleff, Office Engineer	60	60	60	60			
C. R. I. & P. Ry.	John C. Beye, Locating Engineer	30	60	60	80	120		
C. R. I. & P. Ry.	Garrett Davis, Superintendent	30					60	
C. R. R. of N. J.	Jos. O. Osgood, Chief Engineer		60	60	60	60	60	60
Cornell University	C. L. Crandall, Professor of Railroad Engineering	40						
D. L. & W. R. R.	G. J. Ray, Chief Engineer	20	30	40-50	50-60	60-70		
Erie R. R.	W. M. Dawley, Assistant Engineer	10	60	60	80	100	150	200
G. R. & I. R. R.	F. J. Stimson, Engineer Maintenance of Way	50	66	66	66	75		
Grand Trunk	H. G. Kelley, Chief Engineer	30	40	40	60	60	80	120
I. C. R. R.	H. R. Safford, Chief Engineer Maintenance of Way	30	40	60	80	100	120	150
I. C. R. R.	C. W. Pifer, Roadmaster	50	50	50	60	70	80	90
L. & A. R. R.	F. W. Green, General Superintendent	33	33	66	99			
L. I. R. R.	J. B. Austin, Jr., Engineer Maintenance of Way	50		100	150	225	280	300
L. & N. R. R.	J. F. Burns, Roadmaster	30	40	40	40	40		
L. S. & M. S. Ry.	Willard Beahan	100						
Lehigh Valley	E. B. Ashby, Chief Engineer	50	60	60	60	60	90	100
M. K. & T. Ry.	S. B. Fisher, Chief Engineer		40	50	50			
N. C. & St. L. R. R.	Hunter McDonald, Chief Engineer	15	40	40	45	50	55	60
N. Y. C. & H. R. R. R.	G. W. Kittredge, Chief Engineer	30	60	120	120	120	120	120
P. & L. E. R. R.	J. A. Atwood, Chief Engineer	10	15	30	35	40	45	50
P. & L. E. R. R.	Edwin F. Wendt, Assistant Engineer	10	15	(28)	(36)	(38)	(49)	(56)
Penna. Lines West	W. C. Cushing, Chief Engineer Maintenance of Way		60	60	60	60	60	60
Penna. Lines West	R. Trimble, Chief Engineer Maintenance of Way		60	60	60	60	60	60
Penna. Lines West	Frank Rhea, Engineer Maintenance of Way	60	60	60	60	60	60	60
Philippine Railways	Wm. B. Poland, Vice-President and Chief Engineer	30						
St. L. & S. F. R. R.	C. D. Purdon, Consulting Engineer		30	30				
Seaboard Air Line	J. C. Nelson, Engineer Maintenance of Way	25	75	100	120	140	160	180
Transcontinental	D. MacPherson, Assistant Chief Engineer	30		60	60	80	96	120
W. P. Ry.	V. G. Bogue, Vice-President and Chief Engineer	20	30	60	60	60		
	Highest	66	80	120	150	225	280	300
	Lowest	10	15	28	35	38	45	50
	Mean	31	46	55	64	74	89	99

REPLIES TO CIRCULAR NO. 102.

Is spiral made part of permanent alinement in new Location?	*In new location, choice of spirals is governed mainly by*
A., T. & S. F. Ry., J. M. Meade, Eng. E. Gr. Div...Yes	Speed if between 30 and 60 miles. (Speed and topography when speed is over 60; Degree of Curve when it limits speed.)
A., T. & S. F. Ry., C. A. Morse, Chief Engineer ....Yes	Speed and Degree of Curve. (Latter evidently only as it affects length of spiral, not choice of spirals.)
Boston & Maine, J. P. Snow, Bridge Engineer .... No	
B. & O. R. R., H. R. Talcott, Engr. of Surveys ....Yes	Topography occasionally, where offset affects cost. Speed and Degree of Curve where distance between curves permits. (Latter evidently applies only to length of spiral.)
B. & O. R. R., A. W. Thompson, Chief Engr. M. of W...Yes	Speed.
B. & O. R. R., G. D. Brooke, Asst. Engineer ....Yes	Speed. Topography only when necessary on account of short tangents. Degree of Curve only as it limits speed.
B. & O. R. R., J. B. Jenkins, Asst. Engineer ....Yes	Highest speed the line is good for. Degree of Curve to the extent that it limits speed. Topography only when obstructions necessarily fix relative positions of tangent and curve.
B. & O. R. R., E. G. Lane, Engr. M. of Way ....Yes	Topography within certain limits, to be determined on the ground. (Evidently governed by speed, except as limited by topography.)
B. & S. R. R., H. C. Landon, Engr. M. of W..............	Should be governed entirely by Speed and Degree of Curve.
C., B. & Q. R. R., T. E. Calvert, Ch. Engineer ....Yes	(Letter indicates that speed is first consideration.)
C., B. & Q. R. R., Geo. H. Bremner, Engr. M. of W....Yes	(Question misunderstood. Evidently governed by speed.)
C., C., C. & St. L., A. L. Kuehn, Engr. Trk. and R'dway. No	Speed and Degree of Curve. (Latter applies only to length of spiral. Diagram submitted shows that speed governs.)
C., C., C. & St. L., R. Ferriday, Engr. M. of W., P. & E. Ry.............. No	Speed, Degree of Curve and Grade of Approach. (Letter shows that speed alone governs choice, as speed fixes Grade of Approach and Degree of Curve affects length only.)
Cornell University, C. L. Crandall, Prof. of R. R. Engineering...... No	Mainly by speed and degree of curve. Topography somewhat.
C. P. R., F. P. Gutelius, Asst. Ch. Engineer ....Yes	Topography, Speed and Degree of Curve within above limits. (Question misunderstood.)
C., R. I. & P. Ry., A. K. Shurtleff, Office Engineer...Yes	Limit speed on curves to 50 miles; and on 3° and over to from 40 to 45 miles. Use 35-mile and 50-mile spirals.
C., R. I. & P. Ry., Garrett Davis, Supt.............. No	Speed. Not by topography except in mountainous country.

REPLIES TO CIRCULAR NO. 102—Continued.

C., R. I. & P. Ry., John C. Beye, Locating Engineer..Yes	Speed. 25 miles for rough mountain lines, 40 miles for main lines. As a rule, spirals do not determine the choice of location.
C. R. R. of N. J., Joseph O. Osgood, Chief Engineer...	(Letter indicates that speed is the first consideration.)
D., L. & W. R. R., G. J. Ray, Chief Engineer.......... No	Choose spirals so that rate of rise shall be about 1½ inches per second.
E. P. & S. W. Ry., J. L. Campbell, Engr. M. of W...	(Letter indicates that speed governs except in rare cases where topography limits length of spiral.)
Erie R. R., W. M. Dawley, Assistant Engineer ....Yes	Speed and Degree of Curve. (Latter evidently only as it affects elevation and length of spiral, not choice of spiral.)
G. R. & I. R. R., F. J. Stimson, Engr. M. of W....Yes	Speed when above 40 miles. Degree of Curve when over 3°.
Grand Trunk, H. G. Kelley, Chief Engineer ....Yes	1st, Degree of Curve; 2d, Topography; 3d, Speed. For the reason that Degree of Curve and Topography are present factors, while Speed is an indeterminate factor of the future.
I. C. R. R., H. R. Safford, Ch. Engr. M. of W.........Yes	Topography, Speed and Degree of Curve. The value of each of these factors will vary according to local conditions. The best possible combination should be sought in each case.
I. C. R. R., C. W. Pifer, Roadmaster.Yes	Speed.
L. & A. R. R., F. W. Green, General Supt.......... No	Topography within limits of economical practicability. Speed within minor limits. Degree of Curve within variable limits.
L. I. R. R., J. B. Austin, Jr., Engr. M. of W.......... No	"High Speed, over 2°; Degree of Curve, over 2°." (2° probably refers to minimum curve spiraled, and Degree of Curve probably affects length only.)
Lehigh Valley, E. B. Ashby, Chief Engineer ....Yes	Speed should determine within practically no limit.
L. S. & M. S. Ry., Willard Beahan, Asst. Engineer....Yes	Degree of Curve, 0° 3′, up to maximum curve of line. (Question misunderstood.)
M., K. & T. Ry., S. B. Fisher, Chief Engineer .... No	(Rules submitted show that choice of spirals is governed by Degree of Curve alone.)
N. C. & St. L. R. R., H. McDonald, Chief Engineer...	(No new lines. Spiraling of old track governed largely by topographical conditions.)
N. & W. R. R., C. C. Wentworth, Prin. Asst. Engr.. No	(Letter indicates that speed governs.)
N. Y. C. & H. R. R. R., G. W. Kittredge, Ch. Engr..	(A single spiral whose length is 100 feet per degree of curve is used for all curves from 1° to 2°, irrespective of speed. For curves of over 2° a uniform length of 200 feet is used.)
P. & L. E. R. R., J. A. Atwood, Ch. Engineer ....Yes	Speed and Degree of Curve. (Latter evidently only as it limits speed.)

REPLIES TO CIRCULAR NO. 102—Continued.

P. & L. E. R. R., Edwin F. Wendt, Asst. Engineer.....Yes	Speed up to 7-in. elevation. Degree of Curve only as it limits speed.
Penna. Lines West, W. C. Cushing, Ch. Eng. M. of W. Yes	Speed and Degree of Curve. (Latter evidently refers only to minimum curve spiraled.)
Penna. Lines West, R. Trimble, Ch. Engr. M. of W...	(Rules submitted show that speed is the only consideration.)
Penna. Lines West, Frank Rhea, Engr. M. of W..........	Length of spiral=.04080 D V^3. (Choice of spiral depends solely on Speed.)
Philippine Railways, Wm. B. Poland...Yes	
St. L. & S. F. R. R., C. D. Purdon, Consult. Engr..... No	(Three spirals used, dependent on three classes of Speed.)
Seaboard Air Line, J. C. Nelson, Engr. M. of W...Yes	Degree of Curve, 1° and over. (Question evidently misunderstood as applying to minimum curve spiraled.)
Transcontinental, D. MacPherson, Asst. Ch. Engr....Yes	Speed and Degree of Curve.
W. P. Ry., V. G. Bogue, Vice-Prest. and Chief Engr...Yes	Topography until it affects cost. Degree of Curve until it affects cost or shortens tangents below permissible length.

REPLIES TO CIRCULAR NO. 102.

Name of Road and Member.	*In your experience, what per cent. can the speed be exceeded, without discomfort, over the calculated speed for which the rails are elevated?*
A., T. & S. F. Ry., J. M. Meade, Engr. E. Gr. Div................	25 per cent. over actual calculated.
A., T. & S. F. Ry., C. A. Morse, Chief Engineer..................	About 15 per cent.
B. & O. R. R., H. R. Talcott, Engineer of Surveys...............	100 per cent. A 30-mile superelevation can be run over at 60 miles per hour very comfortably on a 3° curve.
B. & O. R. R., A. W. Thompson, Chief Engr. Maintenance of Way.	Maximum safe speed.
B. & O. R. R., J. B. Jenkins, Assistant Engineer..............	20 per cent. on curves which have about 8 inches elevation.
B. & O. R. R., E. G. Lane, Engineer Maintenance of Way........	Have not made any decision to my own satisfaction.
B. & S. R. R., H. C. Landon, Engineer Maintenance of Way.....	About 20 per cent.
C., B. & Q. R. R., George H. Bremner, Engr. Maintenance of Way.	20 miles per hour.
C., C., C. & St. L., A. L. Kuehn, Engineer Track and Roadway...	Varies with curvature, speed and track line and surface. May be extended 10 per cent. in high speeds and good track conditions, and may be extended 50 per cent. in low speeds and good track conditions.

REPLIES TO CIRCULAR NO. 102—Continued.

C., C., C. & St. L., R. Ferriday, Engr. M. of W., P. & E. Ry....	Not over 10 per cent.
C., I. & L. Ry., A. S. Kent, Division Engineer..................	25 per cent.
C. P. R., F. P. Gutelius, Assistant Chief Engineer...................	25 per cent.
C., R. I. & P. Ry., A. K. Shurtleff, Office Engineer...................	Could not state. Have passed over a "35-mile" spiral at 50 miles per hour without shock or discomfort.
C., R. I. & P. Ry., Garrett Davis, Superintendent....................	20 per cent.
C., R. I. & P. Ry., John C. Beye, Locating Engineer...............	About 40 per cent.
C. R. R. of N. J., Joseph O. Osgood, Chief Engineer............	Our experience shows that the speed for which rails are elevated can be exceeded by 25 per cent. without discomfort.
D., L. & W. R. R., G. J. Ray, Chief Engineer...................	15 per cent. to 25 per cent., using the lower percentage for higher speeds and the higher for the lower speeds.
E. P. & S. W. Ry., J. L. Campbell, Engineer Maintenance of Way...	If the elevation of a curve is properly adjusted to 40 miles per hour, I think a train can pass over it at 50 miles per hour without appreciable discomfort to passengers.
Erie R. R., W. M. Dawley, Assistant Engineer.....................	25 per cent.
G. R. & I. R. R., F. J. Stimson, Engineer Maintenance of Way...	20 per cent., or 48 miles, where elevated for 40 miles per hour.
Grand Trunk, H. G. Kelley, Chief Engineer	20 per cent.
I. C. R. R., H. R. Safford, Chief Engineer Maintenance of Way...	25 per cent.
L. & A. R. R., F. W. Green, General Superintendent..............	20 per cent.
L. I. R. R., J. B. Austin, Jr., Engineer Maintenance of Way.......	10 per cent.
L. & N. R. R., J. F. Burns, Roadmaster...........................	Ordinarily about 10 miles per hour.
Lehigh Valley, E. B. Ashby, Chief Engineer.........................	25 per cent.
L. S. & M. S. Ry., Willard Beahan, Assistant Engineer...............	20 per cent.
M., K. & T. Ry., S. B. Fisher, Chief Engineer.........................	Think about 50 per cent., but have not observed carefully.
N. C. & St. L. R. R., Hunter McDonald, Chief Engineer..........	Considerable discomfort is experienced in operating train around a 6° curve at 70 miles per hour with an elevation of 8 inches.
N. Y. C. & H. R. R. R., George W. Kittredge, Chief Engineer.......	From observation, I believe that a speed of 25 to 30 per cent. in excess of the calculated speed for which the rails are elevated can be maintained with safety and with but little discomfort.

REPLIES TO CIRCULAR NO. 102—Continued.

P. & L. E. R. R., J. A. Atwood, Chief Engineer..................	Per cent. varies with degree of curve.
P. & L. E. R. R., Edwin F. Wendt, Assistant Engineer...............	In our experience the actual speed allowed should not theoretically require a superelevation exceeding that in the track by more than 3 inches, preferably 2 inches.
Penna. Lines West, W. C. Cushing, Chief Engr. M. of Way....	20 per cent. within practicable speed.
Penna. Lines West, Frank Rhea, Engineer Maintenance of Way...	30 per cent. for small degree curves. Doubt if 6° or 7° curves would allow 30 per cent. increase without some little discomfort.
Philippine Railway Co., Wm. B. Poland, Vice-Pres. and Ch. Engr.	10 to 15 miles per hour.
St. L. & S. F. R. R., C. D. Purdon, Consulting Engineer..............	Have ridden a 3° curve, elevated 4 inches (=45 miles), at 70 miles without discomfort. Equals about 50 per cent. excess. Do not recommend it as a rule.
Seaboard Air Line, J. C. Nelson, Engineer Maintenance of Way..	About 15 per cent.
Transcontinental, D. MacPherson, Assistant Chief Engineer........	I consider that train can be safely run up to 60 miles per hour over track elevated for 40 miles per hour without discomfort to passengers.
W. P. Ry., V. G. Bogue, Vice-President and Chief Engineer...	10 per cent.

Question 1. Minimum Degree of Curve on which Spirals are used.

While the individual replies indicate that this minimum has usually been arbitrarily fixed, yet, the minimum having been so fixed as a result of experience and observation, the average should indicate in a rough way, at least, the actual requirements under varying speed conditions.

The requirements, as indicated by these replies, may be broadly stated:

For sixty miles per hour all curves of 1 degree and over should be spiraled.

For other speeds the minimum curve to be spiraled should vary inversely with the speed.

As the elevation of the outer rail varies directly with the degree of curve and as the square of the speed, and as the time consumed in attaining a given elevation (if at a fixed rate) is inversely as the speed, there appears to be sufficient theoretical grounds to sustain the above indicated relation between speed and minimum curve to be spiraled. But there are other factors which make tenable, at least, arguments in favor of the minimum curve varying in other proportions.

Question 2. Minimum Offset between Tangent and Circular Curve and Minimum Length of Spiral.

The replies to this question are of more interest as indicating the

extremes of opinion or practice than as indicating the requirements of practice.

Some would introduce spirals (presumably only in particular cases) where the offset between the tangent and spiraled curve is only 0.01 ft., while one answer indicates that 1.14 ft. is the smallest offset that would be used. The minimum length of spiral used varies from 15 ft. to 175 ft.

It is difficult to understand the practical use of a spiral with an offset of only 0.01 ft., as the maximum ordinate in this case would be only 0.04 ft. and the engine would travel over the entire length of the spiral before the wheel flange would come in contact with the rail; the only effect would be to slightly decrease the angle of contact.

If it is assumed that half the spiral shall come into play in order to be of material benefit, the minimum offset would be about 0.08 ft. While it is entirely practicable to stake a spiral with a smaller offset and to line track therefor, it would appear that with this offset we are at least approaching the limit of usefulness of the spiral.

The same line of argument applies in some degree to the minimum length of spiral to be used. A thirty-ft. spiral, with degree of curve increasing at the rate of 10° per station, would have an offset of only 0.02 ft.

A 60-ft. spiral would have the following offsets:

10° per station	0.16 ft.
5° per station	0.08 ft.
2° per station	0.03 ft.
1° per station	0.016 ft.

In view of the varying speeds to which these spirals are applicable, it is doubtful if there would be any material difference in the riding qualities of an unspiraled curve and a curve with a spiral 60 ft. long.

It does not appear, however, that a fixed minimum length of spiral would be applicable to all speeds.

Question 3. Safe Minimum Distance for which Elevation should be run out for Low Speeds.

The replies to this question also vary widely. Possibly some of this variation results from a misinterpretation of the question, which might have been better understood if it had read "minimum safe distance."

While some give this distance as high as 66 ft. and several others give 60 and 50 ft., the number of replies which give 10 and 15 ft. indicates that there is no danger of derailment with this rate of runoff if the track is in good line and surface.

The question is one of sidebearing clearances and rigidity of car body.

Your Committee had, at one time, collected considerable data in regard to short runoffs; in no instance where the runoff was 1 in. in 10 ft. or more and the movement slow was there any trouble; in

several cases, with 1 in. in 12 or 12.5 ft., there was a movement of thirty or more trains per day.

In a number of cases where the runoff was 1 in. in 6 ft. to 1 in. in 9 ft. there had been derailments; but these derailments had been so infrequent as to necessarily indicate that they only resulted from a combination of the extraordinarily short runoff with some other defect, either in track or cars.

In this connection attention is called to the letter of Edwin F. Wendt, dated August 3, 1908.

Question 4. The most satisfactory Distance for which Elevation should be run out for Low Speed.

This is not a question of great importance, as the elevation would necessarily be slight, and the total length of runoff therefore small. The wide variation in the replies, though all apparently based on past experience, is somewhat disappointing and confusing.

Your Committee would consider the most satisfactory distance to be the shortest possible distance which would be absolutely safe under all conditions where a speed is not a factor.

Question 5. The most satisfactory Distance for various Speeds.

The replies bear out the well-established principle that the distance per in. of elevation, for the higher speeds, should be arithmetically proportional to the speed; that is, that the elevation should be increased by a given amount per second.

The average of all replies would fix the distance in feet at about 1¼ times the speed in miles per hour, equivalent to a rate of about 1 1-6 in. per second.

The proper ratio between speed and rate of runoff should be very carefully determined, affecting, as it does, the length of all spirals and the offset from tangent to circular curve.

In spiraling old track the amount of offset is an important factor of the cost of the work; if the offset is great it is frequently necessary to make a complete relocation and to construct a new roadbed.

In new location the length of spiral not only has a very great effect on the cost of the line, but, when tangents are necessarily short or when the external distance is limited, it largely determines the degree of curve. For example, if the central angle of a curve is 60 degrees and the total distance available for circular curve and spiral is only 1,600 ft., a spiral whose curvature increases 2 degrees per station would permit a 4° 20′ curve being used, while a spiral increasing 1 degree per station would require a 6-degree curve.

In general, therefore, if it can be shown that a smaller ratio between runoff and speed will give as good results as a larger ratio, the use of the former would not only effect large economies in construction, but would permit the location of a line with lighter curvature, thus increasing the maximum speed.

There can be no doubt as to the riding qualities of a long spiral carefully maintained, but in considering whether shorter spirals will not give good results, with resultant economies, the testimony of those who have satisfactorily used the shorter spirals deserves careful attention.

Your Committee would again refer to the letter of Edwin F. Wendt as being of especial interest.

Question 6. New Location governed mainly by Topography, Speed or Degree of Curve.

This question was partly prompted by the reference of nearly all authors to the flexibility of the spiral in fitting a location to the ground, it being doubted if any general use was made of this property of the spiral, or if any such application was desirable.

While the import of the question was not grasped by all, it is evident from the replies that topography governs the choice of spiral in only very rare and exceptional cases; that schedule speed is the foremost factor in current practice in governing rate of runoff and consequently in governing choice of spiral; but there is a well-defined tendency among a few roads to disregard schedule speed altogether as something that is liable to frequent change, and to make the governing factor either the degree of curve to be spiraled or the maximum speed as limited by the maximum curve.

Question 7. Spirals made part of Permanent Alinement.

The replies indicate that this is the more common practice.

Question 8. Amount which calculated Speed, for which Rails are elevated, may be exceeded without discomfort.

This is so largely a matter of personal opinion as to what constitutes discomfort that the replies of necessity vary widely.

It seems evident that if the theoretical speed is exceeded more than 15 or 20 per cent. on a curve having 8 in. elevation, or if the required elevation exceeds the actual elevation by more than 2½ to 3½ in., there would be discomfort to a considerable proportion of the passengers. While this is a very vague statement, it is doubtful if any more definite conclusion can be reached.

GENERAL DISCUSSION ON SPIRALS.

If spirals are to be made as much a portion of the permanent alinement as the circular curves, something more tangible than the existing schedule speed should be used to determine the nature of spirals to be used in conjunction with various curves.

For example, an elevation of 8 in. would be required on a 3-degree curve for a speed of 63.5 miles per hour. If such a curve were spiraled for a schedule speed of 50 miles per hour, the result would be to permanently limit the speed to 50 miles; while if spiraled for 63.5 miles per hour, the rail could be elevated for any speed below

63.5 miles without change of alinement by changing the rate of runoff *inversely* as the square of the speed.

It may be assumed that adjacent curves may so limit the speed as to prevent the realization of the full speed which could otherwise be attained on the curve in question; but in making such assumption due consideration should be given to the possibility of the sharper curves being so reduced as to make the curve in question the limiting factor as to speed.

If the 3-degree curve cited above were located between two 6-degree curves, which would probably not be reduced, it would be proper to spiral the 3-degree curve for a speed of about 45 miles per hour, as limited by the 6-degree curves; but if the expected traffic were likely to justify the future reduction of these curves and if this would be done without changing the intermediate alinement, then the 3-degree curve should be spiraled for 63.5 miles per hour.

Briefly stated, no spiral should be chosen which will place a limit on speed below that which results from other conditions, and each spiral should be as permanent as its respective circular curve.

An elevation of 8 in. is the maximum recommended as good practice, but it is by no means the most desirable elevation to be used in all cases for the maximum degree of curve.

Similarly there should be some rate of runoff for elevation recommended as the maximum to be used in good practice, even though this rate should not be the most desirable under all conditions.

Other conditions being equal, long spirals adversely affect degree of curve, while light curvature adversely affects the length of spiral. As sharp curves and short spirals are usually the result of the same topographical conditions, the best results are likely to be obtained through a proportionate or equal degree of perfection in alinement as to degree of curve and length of spiral.

Quoting the letter of C. J. Parker, Principal Assistant Engineer of the New York Central & Hudson River Railroad Company:

"The maximum rate of speed at which a train can travel over a curve where the runoff is 1 in. in 120 ft., without disagreeable effects due to too rapid tipping of cars, is 65 to 70 miles per hour, and where the runoff is 1 in. in 60 ft. a speed of 45 to 50 miles per hour."

According to the practice of that road the runoff does not coincide with the spiral; but for light curves and high speeds the runoff is mainly on tangent, while for sharper curves and lower speeds the proportion of runoff on spiral increases and is usually not less than five-ninths. It is seen from this letter, then, that the elevation may be increased much more rapidly on spiral than on tangent without discomfort, the rate on tangent being about ⅝-in. per second or a runoff of 1 in. in a distance in feet equal to about 1¾ times the speed in miles per hour; while with a runoff largely on spiral (but partly on tangent) the rate may be about 1⅛ in. per second.

If it were possible to run all trains at the exact calculated speed for which the rail is elevated, there would be no discomfort from too rapid tipping of the cars or from change in centrifugal force if the elevation began at the beginning of the spiral and reached the full amount at the beginning of the circular curve, no matter how short the runoff might be, as the resultant of centrifugal force and gravity would, at all times, be normal to the plane of the track. If, however, the train is moving at any other than the calculated speed, the resultant of forces will no longer be normal to the track; and the rapidity of movement of this resultant from a normal line will be a measure of the discomfort.

Let V = speed in miles per hour for which rail is elevated.

Let V' = actual speed.

Let E = elevation of outer rail in inches.

Let E' = proper elevation for speed V'.

Let L = length of spiral in feet.

Then, assuming that the tipping of the cars on tangent at the rate of $\frac{5}{6}$-in. per second or 1 in. in $1\frac{3}{4}$ V ft. is the point where discomfort begins,

$$\frac{L}{E-E'} = 1.75\,V' \text{ when } V' \text{ is less than } V$$

$$\frac{L}{E} = 1.75\,V'\left(1 - \frac{E'}{E}\right)$$

$$\frac{L}{E} = 1.75\,V'\left[1 - \left(\frac{V'}{V}\right)^2\right]$$

which becomes a maximum when $V' = V\sqrt{\tfrac{1}{3}}$; substituting this value

$$\frac{L}{E} = 0.68\,V$$

When V' is greater than V,

$$\frac{L}{E'-E} = 1.75\,V', \text{ or } \frac{L}{E} = 1.75\,V'\left[\left(\frac{V'}{V}\right)^2 - 1\right]$$

which gives the following values of $\frac{L}{E}$:

$$\frac{V'}{V} = 1.10 \quad 1.15 \quad 1.20 \quad 1.30 \quad 1.40$$

$$\frac{L}{E} = 0.40\,V \quad 0.65\,V \quad 0.92\,V \quad 1.57\,V \quad 2.35\,V$$

Hence there will be no discomfort from too rapid increase of centrifugal force or too rapid tipping of cars at any speed under 1.15 times the calculated speed if the length of spiral per inch elevation equals two-thirds of the calculated speed in miles per hour.

Although the ratio of $\frac{L}{E}$ to V increases rapidly when $\frac{V'}{V}$ exceeds 1.15, it must be remembered that the point of discomfort is being approached if not overreached through another cause, i. e., insufficient elevation; when $\frac{V'}{V} = 1.40$ the maximum safe speed for 8 in. elevation has been reached.

It is worthy of note that the spirals in use on the Pittsburg & Lake Erie Railroad—and found to be the most satisfactory as a result of twenty years' experiment and experience—have approximately the same ratio ($\frac{L}{E} = 2/3\,V$) that the above theoretical examination would indicate as giving results entirely free from discomfort.

While some discomfort may possibly be added to that already produced by excessive centrifugal force, by a too rapid increase in centrifugal force of a train moving at the maximum safe speed on a curve elevated 8 in. at a rate of runoff of $L/E = 2/3\,V$, the fact that the resulting rate of increase of unbalanced centrifugal force is much below that resulting from the standard of practice on the New York Central Lines, proves that $L/E = 2/3\,V$ will give results within a wide margin of safety under the most adverse speed conditions.

There is naturally some practical limit to the application of the ratio 2/3; for, while the calculated speed for a 20-degree curve with 8 in. elevation is 24.6 miles per hour, it would not be the best practice to increase the elevation at a rate of 1 in. in 16.4 ft., though it is probable that it would be quite safe. While it is difficult to determine what this practical limit should be, the assumption that it is reached when the rate of runoff becomes 1 in. in 30 ft. will not result in unduly lengthening spirals for the sharper curves.

Assuming this rate for speeds of 45 miles and under, calculated for 8 in. elevation and adhering to the principle that each spiral shall be adaptable to the maximum speed, it follows that:

(1) For all curves of 6 degrees and over which are, or are liable through revision of alinement, to become limiting curves as to speed, spirals not less than 240 ft. long should be used, even if it is necessary to increase the degree of curve in order to obtain this length.

(2) For all curves under 6 degrees which are, or are liable through revision of alinement, to become limiting curves as to speed, spirals should be used whose length in feet equals not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 in., even if necessary to increase the degree of curve in order to obtain this length. Such spirals will have a minimum offset between tangent and circular curve of 2.5 ft.

(3) For all curves which are not liable to become limiting curves as to speed, spirals should be used whose length in feet, when the rail is elevated for the maximum possible speed, will be not less than 30 times the elevation in inches nor two-thirds the maximum speed in miles per hour times such elevation in inches. Degree of curve should be increased, if necessary, to obtain this length.

TABLE OF MINIMUM SPIRAL LENGTHS FOR LIMITING CURVES.

Limiting Degree of Curve.	Speed Calculated for 8 Inches Elevation.	Minimum Length of Spiral.	Minimum Length per Degree.
1° 30′	89.9	479.4	319.6
2°	77.9	415.2	207.6
3°	63.6	339.0	113.0
4°	55.0	293.6	73.4
5°	49.2	262.6	52.5
6°	44.9	240	40
8°	38.9	240	30
10°	34.8	240	24
12°	31.8	240	20
14°	29.4	240	17.14
16°	27.5	240	15
18°	26.0	240	13.33
20°	24.6	240	12

TABLE OF MINIMUM SPIRAL LENGTHS FOR MAXIMUM LIMITS OF SPEED FOR 8 INCHES ELEVATION.

Maximum Limit of Speed.	Minimum Length of Spiral per Degree of Curve.
20	7.92
25	12.375
30	17.82
35	24.255
40	31.68
45	40.095
50	55.00
55	73.205
60	95.04
65	120.835
70	150.92
75	185.625
80	225.28
85	270.215
90	320.76

The lengths in the above tables may be taken as the minimum length, as nearly as may be determined, which will give satisfactory results under all speed conditions; longer spirals may be used when desired, but never at the expense of degree of curve, and only after careful study when cost is affected.

The minimum length of spiral for any curve may be expressed by the two formulas:

$L = .0198\ D\ V^2$ when $V = 45$ or under, and

$L = .00044\ D\ V^3$ when $V = 45$ or over, where L = length of spiral in feet, D = degree of curve, and V = speed for existing or probable future limiting curve, calculated for 8 in. elevation.

It is becoming common practice to limit elevation to 6 in. on maximum curves; the above rules, applied to this practice, would give a runoff of 1 in. in not less than 40 ft. for curves of 6 degrees and over, and approximately 1 in. in a number of feet not less than the speed in miles per hour, calculated for an elevation of 6 in. for curves under 6 degrees, with resultant tipping of cars at a rate not exceeding 1½ in. per second.

To illustrate the practical limit to which the spiraling of curves may be carried, I submit the following table:

TABLE SHOWING THE RELATIVE LENGTHS OF SPIRALS AND SPIRAL OFF SETS REQUIRED FOR VARIOUS CURVES WITH 2 INCHES MAXIMUM ELEV.

D	E	V	L	o
0° 15′	2″	110.1	146.8	0.04
0° 30′	2″	77.9	103.8	0.04
0° 45′	2″	63.6	84.75	0.04
1° 00′	2″	55.0	73.4	0.04
1° 15′	2″	49.2	65.65	0.04
1° 30′	2″	44.9	60.0	0.04
2° 00′	2″	38.9	60.0	0.05
3° 00′	2″	31.8	60.0	0.08
4° 00′	2″	27.5	60.0	0.10
5° 00′	2″	24.6	60.0	0.13
10° 00′	2″	17.4	60.0	0.26
15° 00′	2″	14.2	60.0	0.39
20° 00′	2″	12.3	60.0	0.52

Your Committee would recommend that all curves be spiraled which would require 2 in. elevation for the highest possible speed.

Under this rule, taken together with the preceding rules as to length of spiral, it follows that no spiral will have a length of less than

60 ft. nor an offset of less than one-half in. between tangent and circular curve; any additional statement of the restriction as to minimum degree of curve to be spiraled is thus seen to be unnecessary.

SPIRAL FORMULAS.

PROGRESS REPORT.

All formulas for spirals which have been published or which have come into general use, so far as they have been examined by your Committee, appear to be open to one of these objections:

(1) They are too complicated for convenience in field work and in calculations.

(2) They are in the form of infinite series, giving slightly varying results dependent on the number of terms used.

(3) They are roughly approximate and not mathematically related one with another.

These faults are largely inherent in the spiral itself; and the derivation of simple and accurate formulas is further complicated by the formula for the radius of a simple curve, $R = 50 \text{ cosec } \frac{1}{2} D$.

It is evident that no simple, and at the same time mathematically exact, formulas can be found to express the relations between various functions of the spiral, if it is to be measured by chords of unvarying length, as of 100 ft. The spiral must be considered as being measured (a) along the arc, or (b) by chords having a fixed relation to the deflections for all spirals, or (c) by a uniform number of equal chords.

A spiral based on (a) is most capable of theoretical examination, but produces formulas in the form of infinite series and has the additional disadvantage that it is impracticable to make the field methods conform with the theory when large central angles are involved.

A spiral based on (b) is inconvenient for field use, requiring too wide a variation in length of chord for different spirals.

A spiral based on (c) is readily examined as to the relation between its functions, the calculated spiral is capable of being reproduced on the ground in exact conformity with the theory, and such deviation from the theoretical chord lengths as may be made for convenience in field work involve only a fractional part of the inaccuracy that is inherent in spirals based on (a) and (b).

If all spirals are theoretically considered as being measured in ten equal chords, it will be found that when a short spiral or a spiral with small central angle is measured in a smaller number (either whole or fractional) of chords, or when any spiral of large central angle is measured in chords roughly approximating one-tenth the length of spiral, the resulting error is negligible and much smaller than the error resulting from the difference between chord-measurement and arc-measurement. For spirals of extreme length, stakes may be set at half-chord intervals by measuring alternately half-chord and full-chord distances, the latter only roughly approximating one-tenth the spiral length

when it is desired to use a chord length which is an aliquot part of 100 ft.

Let L = length of spiral in feet, measured in ten equal chords.

C = long chord of spiral.

D = degree of circular curve.

R = radius of circular curve.

I = angle of intersection between tangents.

$\triangle$ = central angle of spiral.

A = deflection from tangent to long chord.

$B = \triangle - A$ = deflection from long chord to a line tangent to the end of spiral.

X = abscissa of end of spiral.

Y = ordinate of end of spiral.

U = longer tangent of spiral only.

V = shorter tangent of spiral only.

Z = abscissa of beginning of offsetted curve.

o = offset = ordinate of beginning of offsetted curve.

T_s = tangent distance of spiraled curve from beginning of spiral to point of intersection of tangents (P. I.)

E_s = external distance of offsetted curve.

Then

(1) $\triangle = \dfrac{LD}{200}$

(2) $A = 1/3\,\triangle - (.003\,\triangle^3)$ seconds, the $\triangle$ in parentheses being expressed in degrees; this formula is approximate, but the greatest error is only two seconds when $\triangle$ is 50 degrees or under.

(3) $B = \triangle - A$

(4) $C = L\,(\cos 3/10\,\triangle + .004 \text{ exsec } 3/4\,\triangle)$. This formula is approximate, but with no error exceeding one part in one million when $\triangle$ is 40 degrees or under.

(5) $X = C \cos A$

(6) $Y = C \sin A$

(7) $U = C \dfrac{\sin B}{\sin \triangle}$

(8) $V = C \dfrac{\sin A}{\sin \triangle}$

(9) $Z = X - R \sin \triangle$

(10) $o = Y - R \text{ vers } \triangle$

(11) $T_s = (R + o) \tan \tfrac{1}{2} I + Z$

(12) $E_s = (R + o) \text{ exsec } \tfrac{1}{2} I + o$

With the exception of (2) and (4) all the above formulas are theoretically exact. These formulas provide the means of obtaining an accurate value of any spiral function, but most of them are not adapted to general field use on account of involving the determination of C.

The Committee has nearly completed a series of simple formulas for all functions in terms of $\triangle$ and L only, which are not only quite accurate, but are very convenient for field use, but we are unfortunately not ready to submit our report now.

Your Committee would ask that this be received as a progress report only, as we wish to present the derivation of the formulas for A and C, with full demonstration of their accuracy, and to add the direct formulas which are being completed.

This work has been done in conjunction with Prof. William G. Raymond, Dean of College of Applied Science, State University of Iowa, to whose invaluable suggestions and assistance the results are largely due.

Your Committee would recommend changing the Manual of Recommended Practice to read:

MAINTENANCE OF LINE AND ALINEMENT—RECOMMENDED PRACTICE.

(b) Adjustment of Curves with consideration as to Easement Curves:

Easement curves should be used on all curves requiring an elevation of 2 in. or more.

The choice of easement curves should be governed by the ultimate possibilities as to speed, with consideration as to probable revision of the worst features of alinement, rather than by existing schedule speed.

On curves of 6° and over, which are limiting curves as to speed, easement curves not less than 240 ft. long should be used.

On curves of less than 6° which are limiting curves as to speed, easement curves should be used whose length in feet is not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 in.

On curves which are not limiting curves as to speed, easement curves should be used whose length in feet, when the rail is elevated for the ultimate speed, will not be less than thirty times the elevation in inches nor less than two-thirds the ultimate speed in miles per hour times the elevation in inches.

Longer easement curves than the minimum lengths recommended may be used to advantage and often with increased convenience in their application, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration as to the effect on cost. The minimum length should be used in all cases where a greater length would adversely affect the degree of curve.

Easement curves should be used between curves of different degree in the same way that they are used between curves and tangents.

The curve elevation should be run out in the same distance as the length of easement curve, with no elevation on tangent and full elevation on the circular curve.

Any form of easement curve is satisfactory in which the degree of curve increases with the distance; in which the rate of increase in degree of curve can readily be changed to suit each particular case, so that the length of easement curve shall be the same as the distance in which the outer rail is raised from zero to full elevation; which can be run in by deflection or offset, with chords of any desired length, and which is of the general type of Searles, Crandall, Holbrook, Talbot or cubic parabola.

DEFINITION OF DEGREE OF CURVE.

Your Committee issued the following circular to the members of the Association:

(*Circular No. 110.*)

Degree-of-curve is usually defined as the angle subtended by a 100-ft. chord, and the relation between the degree-of-curve and radius, according to this definition, is expressed by the formula $R = 50 \operatorname{cosec} \frac{1}{2} D$.

In running in sharp curves with shorter chords than 100 ft., to correspond with half or quarter stations, a correction is theoretically required for the chord-length; tables for these corrections are usually given in field books.

It has always been a common practice to ignore these corrections and to obtain the radius, for the purpose of computing the tangent distance by dividing 5730 by the degree-of-curve.

In this respect practice is frequently at variance with the fundamental definition.

Following are quotations from several authorities in regard to this practice:

Wellington:

"It is almost universally customary in the best practice to record the radius of a 1° curve as 5730 ft., and to determine the radius of curves of other degrees by the approximate formula $R = \frac{5730}{D}$. More commonly yet, the radius is taken direct from a table, but nothing is ever done with this in practical field work, and it is only of importance for recording on maps or for use in solving problems."

Crandall:

"If curves from 8° to 16° are run with 50-ft. chords, from 16° to 32° with 25-ft. chords, from 32° to 80° with 10-ft. chords, and all sharper than 80° with 5-ft. chords, the above value ($R = \frac{5730}{D}$) will be correct to the nearest foot. All the accompanying tables are computed on this basis."

Talbot:

"The best railroad practice, in the writer's opinion, considers circular curves up to a 7° curve as measured with 100-ft. chords, from 7° to 14° as measured with 50-ft. chords, and from 14° upward as measured with 25-ft. chords. . . . . . With this definition of degree-of-curve, the formula $R = \frac{5730}{D}$ will give no error greater than 1 in 2500. . . . . . Hence the relation $R = \frac{5730}{D}$ will be considered true."

Nagle:

"In practice it is customary to take the radius of a 1° curve as 5730 ft. and to assume the radii to vary inversely as the degree."

Carhart:

Defines degree-of-curve as the angle subtended by a 100-ft. chord, but says it is permissible to run sharp curves with shorter chords; also that $R = \frac{5730}{D}$ is frequently used. His table of radii is based on 50, 25 and 10-ft. chords for curves of over 7°.

Henck:

"The length of a curve is measured by chords, each 100 ft. long. Some engineers prefer a chain of 50 ft. in length, and measure the length of a curve by chords of 50 instead of 100 ft. The chord of 100 ft. has been adopted throughout this article."

Searles and *Webb:*

Use $R = 50 \operatorname{cosec} \frac{1}{2} D$ for all curves.

The formula $R = \frac{5730}{D}$ would be absolutely correct if all chords subtended an arc of 2° 24′ 30″; the length of arc per station would be uniformly 100.0074 ft.; the error in using 100-ft. chords for a 1° curve would be 0.006 ft. per station and would decrease up to a 2° 24′ 30″ curve, where there would be no error; it would then increase to 0.004 ft. for a 3° curve, 0.013 ft. for a 4° curve, 0.024 ft. for a 5° curve, 0.038 ft. for a 6° curve and 0.055 for a 7° curve; it will never be as great as 0.01 per station if the chords used subtend arcs of 3° 40′ or less. By way of comparing the magnitude of this error, it may be stated that a difference of temperature of 15° F. will make a variation in the length of a 100-ft. tape of 0.01 ft.

It has also been proposed by a number of engineers to define the degree-of-curve as the central angle of a 100-ft. arc. One or more field books have already been published on this basis.

The actual difference between the external secants of a 10° curve with 45° central angle, by the several definitions of degree-of-curve, is

REPLIES TO CIRCULAR NO. 110.

(Numbers refer to number of definition preferred—see p. 433.)

Name of Road.	Name and Position of Member.	No.
B. & O. R. R.	H. R. Talcott, Engineer of Surveys	2
B. & O. R. R.	Jenks B. Jenkins, Assistant Engineer	2
B. & O. R. R.	A. G. Boughner, Office Chief Draftsman	1
B. & O. S. W. R. R.	H. M. Church, Division Engineer	1
Carnegie Steel Co.	E. C. Brown, Chief Engineer	1
C. & N.-W. Ry.	C. L. Ransom, Resident Engineer	1
C., B. & Q. Ry.	Geo. H. Bremner, Eng. Maintenance of Way.	1
C., B. & Q. Ry.	T. E. Calvert, Chief Engineer	2
C., C., C. & St. L. Ry.	L. S. Rose, Signal Engineer	1
C., C., C. & St. L. Ry.	A. L. Kuehn, Engineer Track and Roadway.	4
C., C., C. & St. L. Ry.	R. Ferriday, Engineer Maintenance of Way.	1
C., C., C. & St. L. Ry.	O. E. Selby, Eng. of Bridges and Structures.	3
C., C., C. & St. L. Ry.	A. S. More, Engineer Maintenance of Way.	2
C., C., C. & St. L. Ry.	Hadley Baldwin, Superintendent	1
C. P. Ry.	J. G. Sullivan, Assistant Chief Engineer	3
C., R. I. & P. Ry.	J. B. Berry, Chief Engineer	1
C., R. I. & P. Ry.	John C. Beye, Locating Engineer	3
C., R. I. & P. Ry.	Garrett Davis, Superintendent	3
C. R. R. of N. J.	C. H. Stein, Engineer Maintenance of Way.	1
C. R. R. of N. J.	Joseph O. Osgood, Chief Engineer	1
C. V. R. R.	Thomas J. Brereton, Engineer	1
D. & H. R. R.	James MacMartin, Chief Engineer	1
El P. & S. W. System	J. L. Campbell, Eng. Maintenance of Way.	1
Erie R. R.	A. Swartz, Division Engineer	2
Erie R. R.	Geo. H. Burgess, Principal Asst. Engineer.	1
Erie R. R.	W. M. Dawley, Assistant Engineer	3
G. R. & I. Ry.	F. J. Stimson, Engineer Maintenance of Way.	1
G. T. Ry.	Howard G. Kelley, Chief Engineer	*3
I. C. R. R.	S. S. Roberts, Assistant Engineer	1
I. C. R. R.	H. R. Safford, Chief Engineer Main. of Way.	3
K. & W. Va. R. R.	G. S. Plumley, Engineer	4
K. C. M. & O. Ry.	M. P. Paret, Chief Engineer	1
K. C. S. Ry.	A. F. Rust, Resident Engineer	3
K. C. T. Ry.	John V. Hanna, Chief Engineer	1
L. & A. Ry.	F. W. Green, General Superintendent	1
L. & N. R. R.	J. E. Willoughby, Engineer of Construction.	3
L. & N. R. R.	W. H. Courtenay, Chief Engineer	1
L. S. & M. S. Ry.	G. C. Cleveland, Assistant Chief Engineer	1
L. S. & M. S. Ry.	Willard Beahan, Assistant Engineer	1
L. S. & M. S. Ry.	R. O. Rote, Principal Assistant Engineer	1
L. S. & M. S. Ry.	John F. Schwed	2
L. V. R. R.	R. A. Van Houten, Division Engineer	3
M. & O. R. R.	B. A. Wood, Resident Engineer	1
Mex. Cent. Ry.	Lewis Kingman, Chief Engineer	*3
Mich. Cent. Ry.	E. R. Lewis, Division Engineer	1
M., K. & T. Ry.	S. B. Fisher, Chief Engineer	1
Mo. Pac. Ry.	J. R. Leighty, Engineer Maintenance of Way.	2
Mo. Pac. Ry.	W. J. Burton, Division Engineer	1
N. & W. Ry.	Charles S. Churchill, Chief Engineer	*1
N. & W. Ry.	C. C. Wentworth, Principal Asst. Engineer.	1
N. P. R. R.	H. M. Stout, Assistant Engineer	1
N. Y. C. & H. R. R. R.	George W. Kittredge, Chief Engineer	1
N. Y., C. & St. L. R. R.	C. H. Smith, Assistant Engineer	1
N. Y., C. & St. L. R. R.	George H. Tinker, Bridge Engineer	1
N. Y., C. & St. L. R. R.	Albert J. Himes, Assistant Chief Engineer	1
N. Y., N. H. & H. R. R.	George T. Simpson, Division Engineer	1
P. & R. Ry.	J. E. Turk, Division Superintendent	1
P. & R. Ry.	F. S. Stevens, Superintendent	3
P. & L. E. R. R.	Edwin F. Wendt, Assistant Engineer	1
Pennsylvania Lines	Thomas H. Johnson, Consulting Engineer, favors dropping the subject.	
Pennsylvania Lines	W. C. Cushing, Chief Eng. Maint. of Way.	1
Pennsylvania Lines	R. Trimble, Chief Eng. Maintenance of Way.	2
Pennsylvania Lines	J. C. Bland, Engineer of Bridges	*2
P. R. R.	Joseph T. Richards, Chief Eng. Main. of Way	1
P. R. T. Co.	Charles M. Mills, Principal Asst. Engineer	1
S. P., L. A. & S. L. R. R.	R. K. Brown, Engineer Maintenance of Way.	1
Va. Ry.	C. H. Stengel, Designing Engineer	1
Vandalia R. R.	M. P. Tucker, Assistant Engineer	1
W. & L. E. R. R.	H. T. Douglas, Jr., Chief Engineer	3
W. P. Ry.	V. G. Bogue, Vice-President and Chief Eng.	3
College of Applied Science, Iowa State University	W. G Raymond, Dean	3
Mass. Inst. of Technology	C. Frank Allen, Professor of Ry. Eng	1
S. E. Coombs	Civil Engineer	1
F. W. Scarborough	Consulting Engineer	2
Walter Loring Webb	Consulting Engineer	1

Totals: Definition	(1)	47
"	(2)	10
"	(3)	15
"	(4)	2
Favor dropping subject		1

Definition (4): For curves up to 7°, degree of curve is the angle subtended by 100-foot chord; for curves of 7° to 14°, by a 50-foot chord, etc.

While voting for other definitions, this or equivalent practice is indicated by * in the tabulation of replies.

less than 0.06 ft. and rapidly decreases for lighter curves and smaller central angles.

In view of this variance in theory and practice, the Committee on Track desires, as a guide in the preparation of tables and formulas, an expression from the members of the Association as to which of the three following definitions and formulas should be accepted:

(1) Degree-of-curve is the angle subtended by a 100-foot chord. Formula $R = 50 \operatorname{cosec} \frac{1}{2} D$.

(2) Degree-of-curve is the central angle of an arc whose length is 100.0074 feet and is equal to 5730 feet divided by the radius.

Formula $R = \dfrac{5730}{D}$

(3) Degree-of-curve is the central angle of a 100-foot arc.

Formula $R = \dfrac{5729.58}{D}$

The poll of the members of the Association shows that a substantial majority favor definition (1):

"Degree of Curve is the angle subtended by a 100-ft. chord. Formula $R = 50 \operatorname{cosec} \frac{1}{2} D$."

Your Committee would recommend that this definition be adopted.

DEFINITION OF DEGREE OF CURVE.

By C. FRANK ALLEN, Professor of Railroad Engineering, Massachusetts Institute of Technology.

With relation to the definition of the Degree of Curve, the subject of a recent circular from the Committee on Track, it may be of interest to review what has been the practice in this matter.

As early as 1829, S. H. Long, of the Board of Engineers of the Baltimore & Ohio Railroad, issued a "Railroad Manual" in which the sharpness of curve was defined by the angle of deflection made between two chords of 100 ft. This was called by him the "Primary Angle of Deflection," and is the same in amount as the "Degree of Curve" of later days. This manual apparently fixed the practice of laying out curves as it still exists in this country, and the chord of 100 ft. determined the angle which we now call the Degree of Curve.

A later book, by S. W. Mifflin, Civil Engineer, in 1837, explicitly defines the "Degree of Curve" as the angle at the center subtended by a chord of 100 ft.

The next field book or book of "Field Practice" was that of J. C. Trautwine (1851). His book made no change in the practice. The radius of a 1-degree curve is given in his tables as 5730, which is correct to 4 significant figures; the radius of 10-degree curve is 573.7; 20-degree curve, 287.9; 40-degree curve, 146.2; all consistent with the 100-ft. chord basis.

Next came Henck's Fieldbook (1854), which defines the degree of curve as the angle subtended by a chord of 100 ft.

Shunk's Field Engineer was published in 1879. This also has tables of radii consistent with the chord of 100 ft. 5729.6 for 1 degree curve; 573.7 for 10 degree curve; 287.9 for 20 degree curve.

Searles' Field Engineering (1880) adopts the prevailing practice, based on the chord of 100 ft.

Tables for Field Engineers, by Stiles, were published in 1885. This book uses 5730 as the radius of 1 degree curve, but has 573.686 for 10 degree curve; 287.939 for 20 degree curve; and 146.190 for 40 degree curve; based on the chord of 100 ft.

Hardaway's Pocket Book of Tables and Formulas for Railroad Engineers (1886) has radii for 1 degree curve 5729.65; 10 degrees, 573.686; 20 degrees, 287.939.

The Civil Engineer's Fieldbook, by Butts (1886), also has radius 1 degree curve 5729.65, and 10 degrees, 573.686.

The Railroad Engineer's Fieldbook, by Godwin (1890), like the two preceding, is on the basis of the chord of 100 ft.

The Engineer's Fieldbook, by Cross, copyrighted 1893 (but probably reprinted from an earlier edition), uses 5730 for the radius of a 1 degree curve, and for others $\frac{5730}{D}$, but the editor of this 1893 edition gives a table of radii based on the chord of 100 ft., which he suggests should be used to give accurate results.

Carhart's Fieldbook for Civil Engineers (1893) uses as a basis for the radii: a chord of 100 ft. from 1 degree to 7 degrees, inclusive; 50 ft., 8 degrees to 14 degrees, inclusive; 25 ft., 15 degrees to 28 degrees; and 10 ft. for greater degrees. His tables give radius 1 degree curve 5729.65; 10 degrees, 573.14; 20 degrees, 286.57 (instead of 5729.65, (573.69, and 287.94).

Nagle's Field Manual for Railroad Engineers (1897) also uses this basis, 100 ft. chord up to 7 degrees; 50 ft., 7 degrees to 14 degrees; 25 ft., 15 degrees to 28 degrees; and 10 ft., above 28 degrees.

Webb's Railroad Construction (1899) is based on a chord of 100 ft.

Philbrick's Field Manual for Engineers (1901) uses an arc of 100 ft. as the basis; giving thus the radius of a 1 degree curve, 5729.58; 10 degrees, 572.958; 20 degrees, 286.479.

Allen's Field and Office Tables (1903) are based on the chord of 100 ft.

Smith's Railway Curves (1905) uses 5730 ft. 1 degree curve; 573.7 for 10 degrees; 287.9 for 20 degrees; 146.2 for 40 degrees. This is on the basis of the chord of 100 ft.

Henderson's Railroad Curve Tables (1906) are also on the basis of the 100 ft. chord.

It will thus be seen that the practice, so far as these tables for

circular curves can fix it, has been well-nigh uniformly on the basis of the chord of 100 ft. Some of these tables, such as Henck's and Searles', have been standard for many years, and it seems unfortunate to disturb existing standards.

It is comparatively recently that any departure has been made from the original basis, and it is noteworthy that where the old basis has been abandoned, it is nearly true that each writer has adopted an independent system. For instance, Nagle (in this case Carhart also) uses a chord, but of different lengths: 100, 50, 25, 10, depending on the sharpness of curve. Philbrick uses the arc of 100 ft. Cross apparently used $\frac{5730}{D}$ for the radius, but the editor of the 1893 edition adopts the chord of 100 ft.

Unless the tables of Cross date back of 1893, it appears that the practice as shown by these books of tables remained uniform from 1829 to 1893, a period of 67 years. It certainly seems as if a practice of this duration should be not only respected, but maintained.

Aside from these general tables for railroad practice, there have been published several pocketbooks specially devoted to spirals.

Of these, Searles' Railroad Spiral (1882) naturally agrees with his Field Engineering, and uses the chord of 100 ft.

Howard's The Transition Curve Fieldbook (1891) adopts the same basis.

Fox, Transition Curves (1893), does the same.

Crandall's, The Transition Curve (1893), uses for the radius $\frac{5730}{D}$, suggesting that if curves from 8 degrees to 16 degrees be run with 50 ft. chords; 16 degrees to 32 degrees, 25 ft.; and all sharper than 32 degrees with 10 ft. chords, the value of $R = \frac{5730}{D}$ "will be correct to the nearest foot." He has tables of radii computed on this basis.

Talbot, in his Railroad Transition Spiral (1901), uses $\frac{5730}{D}$ as giving no error greater than 1 in 2,500, on the basis of using in the field, chords of 100 ft. up to a 7 degree curve ; 50 ft. from 7 degrees to 14 degrees; 25 ft. from 14 degrees upward; he adopts 50 ft. chords for the 7 degree curve, while Nagle retains 100 ft. chords for 7 degree curves. Talbot has no table of radii.

Stephens, in the Six Chord Spiral (1907), uses $R \frac{5730}{D}$, and gives a table of radii on this basis.

It makes little difference in the sharpness of the curve whether the radius of a 10 degree curve be 573 ft. or 573.7; but it is important that all the calculations and measurements shall be consistently on the same basis. In determining the properties or deriving the formulas of the transition curve or spiral, it makes little difference which degree is used. In connecting with a 6 degree circular curve it is unimportant whether the spiral has reached to a 6 degree curvature, or only to a 5°59′, or a 5°58′, or perhaps a 5°50′ curvature. An important feature, however, is that the circular curve and the spiral shall have a common tangent where they connect.

Although for circular curves, it matters little for use whether the curve has a radius of 818.57 ft. or 819.02 ft., yet it is important that all the work be consistent, and in a departure from the old, established basis some curious results have occurred.

For instance, in one of the books of tables mentioned above, the radii are on a basis of 100 ft. chords to 7 degrees; 50 ft. to 14 degrees; 25 ft. to 28 degrees; but the table of long chords is on the basis of 100 ft. chords throughout; and the table of tangent distances is accompanied by a table of corrections to reduce the result to the 100 ft. chord basis. Two of these books have the radius of a 6°60′ curve = 819.02, and the radius of a 7 degree curve = 818.64; also the radius of a 13°60′ curve = 409.51, and 14° = 400.32.

Another inconsistency will appear if we consider the case of a 7 degree curve, 9 stations long, having thus an intersection angle of 63 degrees, which is not a very extreme case. Using the chord of 100 ft. as a basis, the radius is 819.02; using $\frac{5730}{D}$ it is 818.57, or 0.45 smaller; not a large amount.

Yet the tangent distance kb will be smaller than ka by ab = 0.276 ft. From the P. C. at b, the curve will be run out by chords of 100 ft. and with deflection angles of 3°30′, 7°, 10°30′, etc.; that is, with a radius of 819.02 ft., and the resulting curve will be, not bc, but be, and the P. T. of this curve will be outside the tangent by ef = 0.246 ft.; and the curve will also be longer than bc, and will over-run the point c to the extent that cf = 0.401 ft.

Here $R - R^1 = 0.45$.

$$\begin{aligned} ab &= 0.45 \tan 31°30' = 0.276 = oo'' = de. \\ ef &= 0.276 \sin 63° = 0.246. \\ cf &= 0.246 \cot 31°30' = 0.401. \end{aligned}$$

As the curve run out in the field lies outside the tangent, the adjustment or fudging naturally resulting will sharpen the curve where it joins the tangent, which is contrary to what is desirable.

The natural errors or lack of precision common to all field-work may sometimes decrease these amounts, but, on the other hand, will sometimes increase the discrepancy.

The fact that the total deflection to $e = 31°30'$, also carries the lines through c, serves to give to the transitman a sense of security not merited, and which is unfortunate. But if an additional set-up of transit is made near the end of curve, the final deflection angle will carry the line outside the P. T., and may lead a careful transitman to repeat his work, but with no better results.

If the intersection angle is 90 degrees instead of 63 degrees, the 7 degree curve will lie outside the tangent (at the P. T.) by ef = 0.45 ft. instead of 0.246.

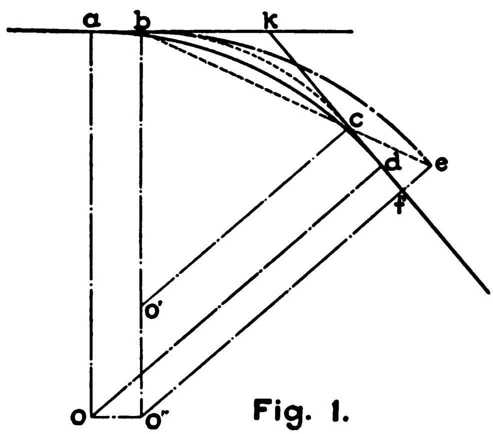


Fig. 1.

The error, whatever its amount, is due to the fact that the tangent distance is figured for a radius of $\frac{5730}{D}$, in this case 818.57, while the curve is run out with chords of 100 ft. and deflection angles of $3°\ 30'$, $7°$, etc., and which are correct only for a radius of 819.02. The length of curve is also that due to a radius of 819.02, and this length is $L = \frac{100\,I}{D}$ (in accordance with universal practice), which is not correct for $R = \frac{5730}{D}$, so that the chaining cannot check.

When the line runs through city property where measurements of streets and lots are made with much precision, there is necessity for similar precision in the railroad line.

Furthermore, with the transit at b (the P.C.) and a foresight taken on the vertex k, the stakes at the various stations around the curve will occupy one set of positions; with the transit at c (the P. T.) and a foresight on k, a second set of positions for the stakes will result; again, with the transit at c (the P.T.) and a foresight on the P.C., a

third set of positions results. There is no certainty nor stability in the position of the curve, no matter how careful and accurate the field-work.

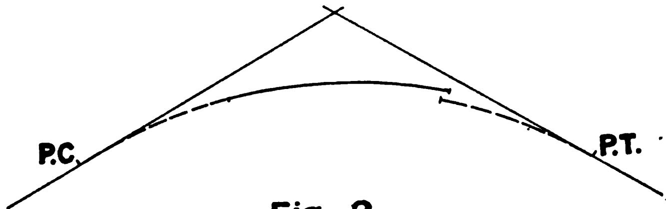


Fig. 2.

Since such a curve does not close properly either in theory or on the ground, there is no practicable way of determining the actual length of arc or of rail, since these are dependent on the method adopted for running in the curve and adjusting the discrepancy.

When an easement curve, a spiral is introduced, the best practice is to have each spiral run from the tangent, and the discrepancy from imperfect fieldwork adjusted where the spiral and the circular curve connect, or on the circular curve altogether. When the spirals are run out in this way the difficulty as to tangent distance and length of curve still exists, if $R = \frac{5730}{D}$ is used.

In the case of the 7 degree curve, if $R = \frac{5730}{D}$ is used, the spiral line at the end will lie inside the circular curve by an amount varying from about 0.2 ft. to 0.4 ft., depending on the intersection angle, whether 63 degrees or 90 degrees.

How will this discrepancy be adjusted? It is not improbable that part of the adjustment will be made in the circular curve, and part in the spiral, which then largely fails of performing its intended functions.

If the fieldwork is done by running in first a spiral, then the circular curve, and then the second spiral (backward), the discrepancy or failure to meet the tangent is likely to destroy entirely the intended purpose of the spiral.

In view of the above considerations, it seems evident that the only satisfactory basis for the degree of curve is to define it as the angle at the center subtended by a chord of 100 ft., as it has been defined by a great preponderance of practice and for so many years.

The characteristic feature of American practice in laying out circular curves is that the unit of measureemnt is 100 ft., and this is applied on curves as the chord; the degree of curve is taken at some simple convenient angle (a degree or half degree), with the result that the deflection angle for the unit of curve measurement, the chord of

100 ft., will also be correct at some simple convenient angle (a degree, or half degree, or quarter degree); the radii and other data are made to correspond.

If the radius be taken as $\frac{5730}{D}$, then it follows that with a chord of 100 ft., the deflection angle for a 7 degree curve is not precisely 3°30'; and, conversely, with a deflection angle of 3°30', the chord is not precisely 100 ft., and the principle which determined American practice is violated and lost.

While the arc of 100 ft. forms a logical and consistent basis for defining the degree of curve, the objection holds that for convenient deflection angles the chords must be less than 100 ft. and of different length for each degree of curve.

The practice of using chords of 100 ft., 50 ft. or 25 ft., depending on the sharpness of curves, introduces other difficulties, and has seldom been consistently followed. That its use in connection with $R = \frac{5730}{D}$ fails to secure correct results, has been demonstrated above.

Measurements around curves in the field must be made by chords. The radii of different curves are not exactly in inverse proportion to the angle at the center subtended by a chord of 100 ft.; this state of facts, although undesirable, is practically unavoidable. Some inconvenience of necessity results either in computation or in fieldwork. Ease of computation in work of this sort must yield to convenience and accuracy of fieldwork, and the basis of the chord of 100 ft. seems best to meet the requirements.

Very little inconvenience, however, results from using the established basis of the chord of 100 ft. Curves cannot well be laid out without the use of tables, and engineers must know the use of logarithms. Several books of tables give directly the logarithms of the radii for different degrees of curve, so that computations depending on the radii are facilitated, and even the computation of the tangent distance is simple and rapid.

The shortest method of computing the tangent distance for ordinary curves is to use tables which give the tangent distance for a 1 degree curve, and find for the given intersection angle the tangent distance for a 1 degree curve and divide by the degree of curve; this gives a value not quite correct; but several of the best field books include also a table of corrections from which the correction can be taken, and an accurate value of the tangent distance secured very expeditiously.

In laying out sharp curves of perhaps 10 degrees upward, the regular stations should be set out by 100 ft. chords. If intermediate points are desired, they can be set simply and with very slight error by measuring from each station chords both of 50 ft. and of 100 ft.

It is possible, if anyone desires it, to use chords of 30.05 for 10

degree curves and 50.19 for 20 degree curves, but with less convenience. Moreover, using the full chords of 100 ft. will secure more precision in trackwork, because with fewer separate measurements entering into the total length, there will be less accumulation of error.

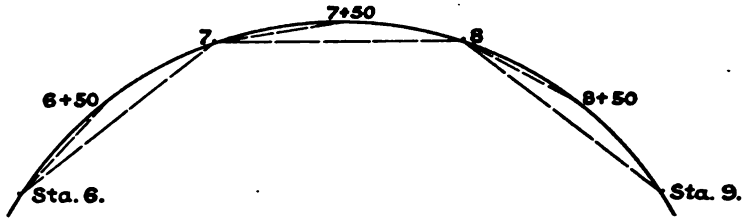


Fig. 3.

With very sharp curves, approximations of all kinds should be used with great caution, even the common approximation that deflection angles are proportional to their chords, may not be allowable.

In determining the properties or deriving the formula of a spiral easement curve, the approximation $R = \frac{5730}{D}$ appears allowable for ordinary railroad work, but probably not for the very sharp curves used on steel railways. For these, multiple compound curves seem to be favored.

The important requirements for the spiral are: First, that the circular curve and the spiral shall have a common tangent *CL* at the point *C*, where they connect; second, that the distances *BD* and *AB* shall be accurately determined with reference to the curve *AC;* and third, that the angles *CAL* and *ACL* shall be determined with sufficient accuracy to fix the position of the point *C* and the direction of *CL*.

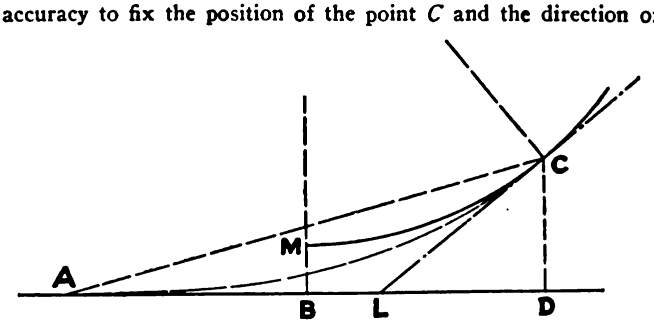


Fig. 4.

It is desirable that the degree of curvature of circle and spiral shall be the same at *C*, but a slight variation in this is unimportant, and $R = \frac{5730}{D}$ is amply good for this purpose.

Unless in Fig. 4 and Fig. 5, the point C, as fixed from A, has the proper relation to M, so that the distance BD is what it should be, the difficulty illustrated in Fig. 1 will again occur; an error of several tenths is not admissible.

It is further essential that the point C should be so set from A that in laying off the angle CAL, the position of C relatively to D shall be correct within close limits; an error of a tenth of a foot would be undesirable.

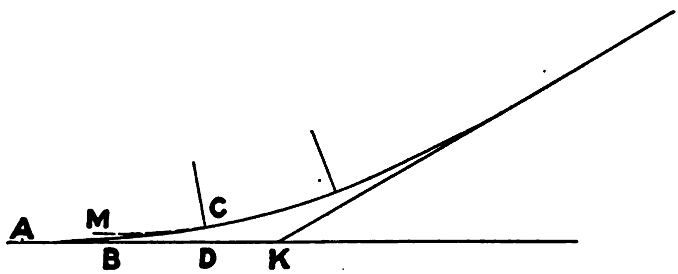


Fig. 5.

It appears to be the case that the approximations commonly made in spiral formulas are within the limits desired for use with ordinary railroad curves. The spirals are not of great length, and the approximations that $R = \frac{5730}{D}$ and that the deflection angles vary as the squares of the distances, are probably satisfactory, if not extended to very sharp curves.

It is further true that when spiral tables have been prepared giving the deflection angles to be used with chords of convenient specified length, there is a substantial compliance with the spirit of the American practice in running curves which makes the degree a controlling element, because in this way there is secured simplicity and accuracy in the relation between the deflection angles and the chord measurements. In the spiral this simplicity is secured, because the angles to be used have been calculated and are recorded in the spiral tables, whose use insures certainty and also accuracy, if the tables have been correctly computed.

The fact that the approximation $R = \frac{5730}{D}$ is used on a spiral curve is not an element which should have any influence in determining the practice on circular curves.

WILLIAM G. RAYMOND, Dean College of Applied Science, State University of Iowa.

In response to Circular No. 110, I vote for the third definition, namely, Degree-of-curve is the central angle of a 100-foot arc. Formula, $R = \frac{5729.58}{D}$.

I think that the circular issued hardly presents the matter fully enough, as no arguments are presented except one favoring the use of $\frac{5730}{D}$, and engineers who have used this formula, I fancy, are in the majority, and will therefore, without thought of what is being done, endorse this formula.

The matter is, of course, not one of life and death, but I am so firmly convinced that the third definition is the more logical, that it is the simpler to use in practically all calculations, that it involves no more work in the field than the second definition, that it approximates very much closer to the second definition, which has been extensively used, than does the first definition, that I should like to have the matter decided after a full presentation rather than in an offhand way on the strength of first impression.

The increasing precision with which trackwork is being performed seems to make it desirable that accurate and logical formulas shall be endorsed as correct, leaving each individual engineer to use such simplified approximations in his constructional work as he may wish to use. It will be noted that the radius of a one-degree curve, under the third definition, has exactly as many feet as there are degrees in a radian of arc, and that this is not true of either the second or first definition. It is this fact that makes the third definition simple of application in various problems.

By the second definition, the length of the proper chord must be computed, since 100 ft. will be incorrect for any other than the very odd degree of 2° 24′ 30″. By the third definition the chords would have to be computed as well, and the fact that there is no particular curve in which a 100-ft. chord will be the proper one, in no wise makes this formula less simple of application than is the second, since, if the chords have got to be computed at all, it makes little difference that some one particular curve which is an odd one, never likely to be used, needs no computation. It is also true that by either one of these formulas, if the chord be made short enough, the curve may be run in by the usual methods of making the deflection angle proportional to the length of the chord. Therefore, nothing is gained by the use of the second over the third, and the third has a logical, mathematical *raison d'etre* which the second has not.

The adoption of $\frac{5730}{D}$, while apparently in conformity with common practice, would really not be much more, if any, in conformity with

common practice than the adoption of $\frac{5729.58}{D}$, because, while possibly the majority of engineers have thought that they adopted $\frac{5730}{D}$, as a matter of fact, they have not used chords in laying out curves that would produce a curve whose radius is $\frac{5730}{D}$. They have approximated to this, but have not attained it. They will in all probability continue to approximate to it, just as they would probably approximate it in any other scheme.

I do not know that it is proper to address this argument to you at this time, or that anything can be done with it, but I trust that before a final vote is taken which shall establish one of these definitions as a standard, some opportunity will be given for arguing the question.

I should like information also as to the advisability of having our tables made for degrees and decimals, and our instruments graduated the same way, say, to read hundredths of a degree. I believe this would be a great convenience, and as I am making a field book, I should be glad to make it in this way if the majority of engineers would consider it worth while. It would mean simply a change in the verniers on existing instruments.

ROBT. FERRIDAY, Engineer Maintenance of Way, C., C., C. & St. L. Railway.

Attached is the interrogatory circular filled out for all but the first two questions. Answers to those questions do not establish the limits desired, because the offset and length of spiral (which are co-ordinate) are functions of the elevation and runoff, or grade of approach, as it is sometimes called. The grade of approach is not usually considered as a function of the speed, but it should be, and should vary inversely with it; as an illustration, assume grade of approach 1 in. in 80 ft. for 80 miles per hour, then the grade of approach for 40 miles per hour should be 1 in. in 40 ft., since the elevation will then be applied at the same rate per unit of time.

An easement curve should be applied when the offset exceeds the minimum, to be determined by your Committee, and as this involves the grade of approach, degree of curve and elevation, I recommend using spiral on all curves of one degree or above which have three inches or more elevation, the grade of aproach to be, where possible, as follows:

1 in. in 30 ft. for 30 miles per hour.
1 in. in 40 ft. for 40 miles per hour.
1 in. in 50 ft. for 50 miles per hour.
1 in. in 60 ft. for 60 miles per hour.
1 in. in 70 ft. for 70 miles per hour.
1 in. in 80 ft. for 80 miles per hour.

It has been my observation that the grade of approach should be for speeds of 60 miles per hour, at least 1 in. in 60 ft.; further, that on spiraled curves of high elevation and speeds, the application of the elevation at as high a rate as 1 in. in 100 ft. gave a most comfortable sensation to the traveler. This grade of approach, I believe, is about the practical maximum, considering present perfection in surface. The following table shows in the first column the grade of approach for various speeds based on the maximum 1 in. in 100 ft. for 80 miles per hour. The second column has been shown for comparison, and is recommended as a practical list, probably fitting present refinement in surface more generally, and as easily to be kept in mind.

Miles per Hour.	Grade of Approach.	Grade of Approach (Practical).
30	1 in. in 37 ft.	30 ft.
40	1 in. in 50 ft.	40 ft.
50	1 in. in 62 ft.	50 ft.
60	1 in. in 75 ft.	60 ft.
70	1 in. in 87 ft.	70 ft.
80	1 in. in 100 ft.	80 ft.

The following table shows the effect of my recommendations with regard to application of easement curve:

Degree.	Miles per Hour.	Elev.	Length of Spiral.	Offset.	Rate of Increase.
1°-00′	67	3 in.	200 ft.	.28 ft.	1° in 210 ft.
1°-30′	55	3 in.	165 ft.	.30 ft.	1° in 110 ft.
2°-00′	47	3 in.	140 ft.	.27 ft.	1° in 70 ft.
3°-00′	39	3 in.	120 ft.	.31 ft.	1° in 40 ft.

The throw of the track at the point of original circular curve is, of course, but one-half the offset, and the application of easement curve would hardly be justified for less throw at the speeds shown.

The following table shows what would be the effect if easement curves were applied to curves of 30 minutes or above which have 2 in. or more elevation:

Degree.	Miles per Hour.	Elev.	Length of Spiral.	Offset.	Rate of Increase.
0°-30′	80	2 in.	160 ft.	.10 ft.	1° in 320 ft.
1°-00′	55	2 in.	110 ft.	.09 ft.	1° in 110 ft.
1°-00′	80	4½ in.	360 ft.	.95 ft.	1° in 360 ft.
1°-30′	45	2 in.	90 ft.	.09 ft.	1° in 60 ft.
1°-30′	80	6¼ in.	500 ft.	2.75 ft.	1° in 330 ft.

The offsets for elevations of 2 in. for the degree as shown when compared with the corresponding speed, do not justify easement curves. The table shows that for high speeds on one-degree curves, easement curves are justified, and when compared with the foregoing table, develops that easements should be applied to curves of one-degree or above, having 3 in. or more elevation, the grade of approach, where possible, to be as given above.

EDWIN F. WENDT, Assistant Engineer, Pittsburg & Lake Erie Railroad.

Answering the Circular No. 102, our judgment is as follows:

For speeds of 30 miles per hour, no spirals are required.

For speeds of 40 to 80 miles per hour, spirals should be applied to all curves shorter than 0° 30′.

In regard to the minimum of feet between tangent and circular curve which it is practicable to use for a spiral, we answer that spiral length should vary as the cube of the speed. Our basis is 60 ft. per degree for 50-mile speed.

The safe minimum distance for which elevation should be run out for low speeds is 1 in. in 10 ft.

The most satisfactory distance is 1 in. in 15 ft.

The most satisfactory distances for speeds of

40 miles per hour is 30 ft. per degree.
50 miles per hour is 60 ft. per degree.
60 miles per hour is 90 ft. per degree.
70 miles per hour is 160 ft. per degree.
80 miles per hour is 240 ft. per degree.

In new locations in the choice of spirals we are governed, not by topography, but by speed within the superelevation limit of 7 in.

In the case of very sharp curves, we adjust the spiral to the speed which is allowed.

In new location work we make the spirals a part of the permanent alinement. In accordance with our experience, the actual speed allowed should not theoretically require a superelevation exceeding that in the track by more than 3 in., preferably 2 in.

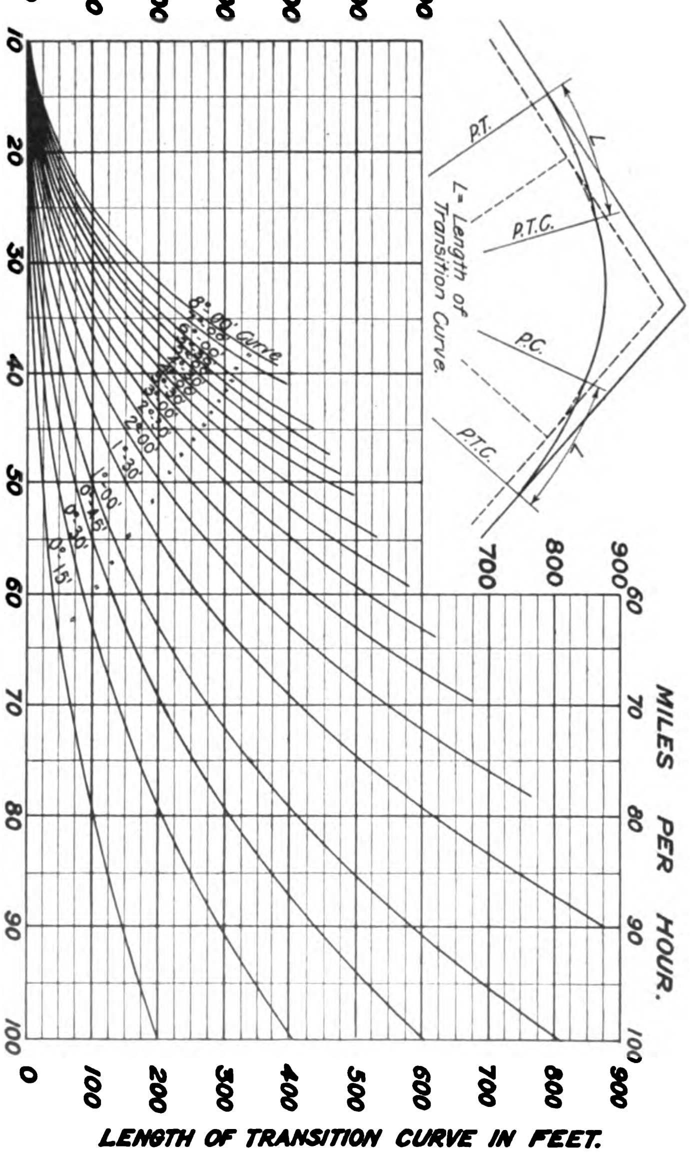
I might say, by way of explanation, that the Pittsburg & Lake Erie began the use of spirals in 1888, just 20 years ago. At that time Elliot Holbrook was General Superintendent of this railroad, and he put into use what is known as the "Holbrook Spiral." Since that time all curves on this railroad have been equipped with spirals of the Holbrook design.

We follow the practice of putting spirals on all curves 1 degree or over, and at the present time I think that practically all curves on this railroad are spiraled. Where speed is maximum we feel that 150 ft. spirals should be used. This we consider our best practice. The general practice, however, at the present time is to use 100-ft. spirals, except at a very few points, where conditions warrant the use of 60-ft. spirals—the element of speed determines our decision.

Since this road has had 20 full years of experience with the use of spirals, we feel that we are warranted in certain conclusions. Referring again to the questions:

(1) The safe minimum distance for which elevation should be run out for low speeds is 1 in. in 10 ft.

We must say that this practice should never be followed except in yards. Such a practice should not be used where the track is not



Proper length of Transition Curve for a 1°00' Curve at 50 miles per hour is 100 ft. Length of Transition Curve varies directly in proportion to the degree of Curve and directly as the cube of the speed.

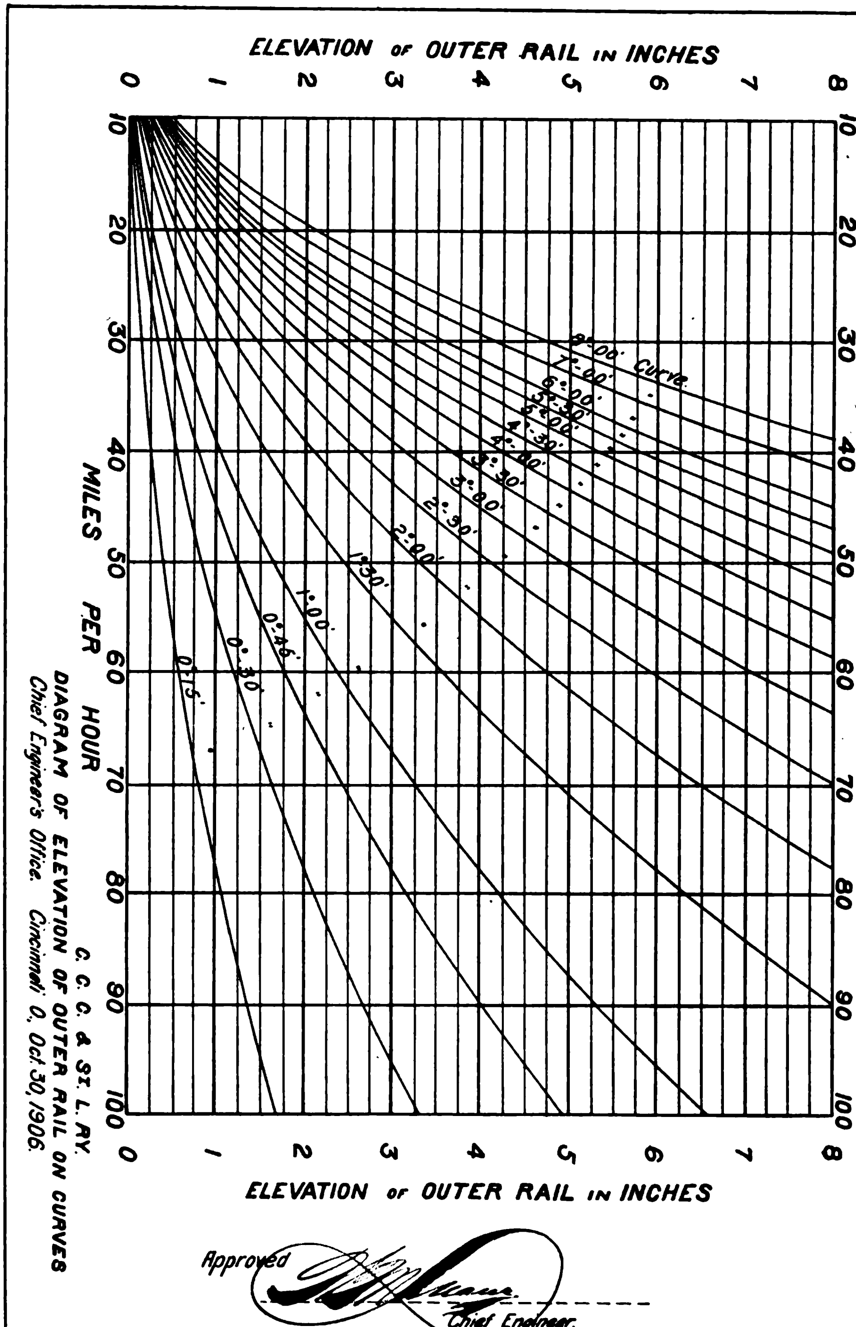
Approved:-

Chief Engineer.

C. C. C. & St.L. Ry.

PROPER LENGTH OF TRANSITION CURVES.

Office of Chief Engineer. Cin'ti, O. 2-6, '08.



C. C. C. & St. L. RY.
DIAGRAM OF ELEVATION OF OUTER RAIL ON CURVES
Chief Engineer's Office. Cincinnati O. Oct. 30, 1906.

kept in good condition. Our practice on the Pittsburg & Lake Eric is to keep yard tracks in good surface, because we find that this pays by enabling the yard to be handled economically. The question asks the "minimum distance," and we answered by using what we consider a minimum, but which is seldom used, if ever, on our road. In other words, in answering the questions, we take them literally. If tracks are in good surface, a change of 1 in. in 10 ft. should not result in derailment. I do not regard this, however, as best practice.

(2) The most satisfactory distance is 1 in. in 15 ft. I would not endorse this practice for many railroads, but we have light curvature here, and our answer refers strictly to sidings, not to main track. Our rule in yards is to elevate very little. For instance, a 3-degree curve in a yard could be operated very well indeed with 1-in. elevation. I think our constant aim should be to elevate tracks in yards just as little as possible.

This whole question of elevation of curves outside of main line is one which is worthy of considerable study. The common practice in some parts of America has been to elevate much more than is necessary. The general rule should be to hold the elevation down to the lowest point consistent with economical movement.

(3) The Committee's interpretation of our answer is practically correct. Our theory is that a moving train rounding a curve should be adjusted to the difference in elevation at a uniform rate.

If you have a 4-degree curve and elevate it for 60 miles per hour, a certain length of spiral will be necessary in order to accomplish the desired end. If, however, a 4-degree curve is elevated for only 45 miles per hour, this is a different proposition.

Ten years ago we used no spiral longer than 60 ft. per degree. Speeds at that time were about 50 miles per hour ordinarily and 60 miles per hour maximum. To-day we find trains running 75 miles per hour right along, and we find it now necessary to use 60-ft. spirals, 100-ft. spirals and 150-ft. spirals, just as conditions require. Our maximum elevation is 8 in. When speed requires more than 8 in. elevation we put a note in the timetable designating the maximum speed which should be run at certain curves. This is a very interesting proposition, and one which we studied very carefully last winter. For instance, 4° 20′ curve elevated for 55 miles per hour will require just about the maximum. We found, however, that trains would round such curves at 75 miles per hour. A close study of the theory of the proposition resulted in a conviction on our part that we should not permit the trains to make this maximum speed. Experience seems to show that ordinarily it would be safe to run at 58 per cent. or at 120 per cent. of the speed for which rail is elevated, as indicated by the question in the Committee's letter, but we do not approve this as good practice.

In regard to the last question in the Committee's letter, the experience which we have gained during the past 20 years has convinced us that for speeds of 60 miles per hour 100-ft. spirals will give good

results. If 75 miles per hour is followed on the open road, we think longer spirals are desirable.

In regard to the cost of maintaining spirals, our view is that we are now in position to maintain curves with spirals just as cheaply as curves without spirals.

In regard to this whole question of spirals, I have seen a little book, by Talbot, called "The Railway Transition Spiral." In that book there is a very valuable discussion of the question of choice of spirals with respect to length, etc. We studied this question and worked out our conclusions, never having seen Talbot's book, but since looking it over we found that Talbot and ourselves practically agree with respect to the question of superelevation. We have come to our conclusions by tempering theory by experience.

GEORGE W. KITTREDGE, Chief Engineer, New York Central & Hudson River Railroad.

Referring to the circular letter of the Committee on Track, dated June 8, 1908, the practice on the New York Central in regard to spirals is such that it is rather difficult to answer the questions as outlined in the circular. I attach a map of our transition curve, K-12, which is in use on this road. It will be noted:

(1) and (2) That the minimum curve to which spiral is applied is 1 degree, and the length of spiral for such a curve is 100 ft. The length of spiral for 1° 30′ curve is 150 ft. and the length for 2-degree curves and over is 200 ft., irrespective of the speed.

(3) A safe minimum distance for which elevations should be run out for low speed is about 1 in. for 30 ft.

(4) The most satisfactory distance for which elevations should be run out for low speed is about ½-in. for 30 ft.

(5) Our rule in regard to runout on curves is as follows: "'Simple' curves shall have full elevation at the point of curve and the same elevation shall be used uniformly for the entire length of the curve. For elevations of 3 in. and under, the rate of the runoff on the tangents shall be one-quarter of an inch per 30 ft. For elevations over 3 in. the runoff shall not exceed 360 ft."

(6) and (7) All the new lines constructed within recent years by the New York Central have been for slow-moving freight trains, so that the question of spirals has not entered largely in the location.

(8) From observation, I believe that a speed of 25 to 30 per cent. in excess of the calculated speed for which rails are elevated can be maintained with safety and with but little discomfort.

C. J. PARKER, Principal Assistant Engineer, New York Central & Hudson River Railroad.

The maximum rate of speed at which a train can travel over a curve where the runoff is 1 in. in 120 ft. without disagreeable effects due to too rapid tipping of cars is 65 to 70 miles per hour, and where the runoff is 1 in. in 60 ft. a speed of 45 to 50 miles per hour.

K12 Issue 1/9

Degree	Radius in Feet.	Length in feet.	Elev. in Inches	Abscissas in feet.				Ordinates in feet.				O in feet.	Chords in feet.			
				x_1	x_2	x_3	x_4	y_1	y_2	y_3	y_4		C_1	C_2	C_3	C_4
1°00′	5729.6	100	2½	25	50	75	100	.01	.04	.12	.29	.07	25.00	25.00	25.00	25.00
1°30′	3819.8	150	3	37½	75	112½	150	.02	.12	.41	.98	.24	37.50	37.50	37.50	37.51
2°00′	2864.9	200	3½	50	100	150	200	.04	.29	.98	2.23	.58	50.00	50.00	50.00	50.02
2°30′	2292.0	"	4	"	"	"	"	.05	.36	1.22	2.91	.72	"	"	"	50.03
3°00′	1910.1	"	4½	"	"	"	"	.05	.44	1.47	3.49	.87	"	"	50.01	50.04
3°30′	1637.3	"	5	"	"	"	"	.06	.51	1.71	4.07	1.01	"	"	"	50.05
4°00′	1432.7	"	5½	"	"	"	"	.07	.58	1.96	4.65	1.16	"	"	50.02	50.07
4°30′	1273.6	"	6	"	"	"	"	.08	.65	2.20	5.23	1.29	"	"	"	50.09
5°00′	1146.3	"	6½	"	"	"	"	.09	.73	2.45	5.82	1.44	"	"	50.03	50.11
5°30′	1042.1	"	"	"	"	"	"	.10	.80	2.69	6.40	1.58	"	"	"	50.13
6°00′	955.4	"	"	"	"	"	"	.11	.87	2.95	6.98	1.73	"	50.01	50.04	50.16
6°30′	881.9	"	"	"	"	"	"	.12	.94	3.19	7.56	1.87	"	"	50.05	50.19
7°00′	819.0	"	"	"	"	"	"	.13	1.02	3.44	8.14	2.00	"	"	50.06	50.22
7°30′	764.5	"	"	"	"	"	"	.14	1.09	3.68	8.72	2.14	"	"	50.07	50.26
8°00′	716.8	"	"	"	"	"	"	.15	1.16	3.93	9.30	2.28	"	"	50.08	50.29
8°30′	674.7	"	"	"	"	"	"	.16	1.23	4.17	9.88	2.41	"	"	50.09	50.33
9°00′	637.3	"	"	"	"	"	"	.17	1.31	4.41	10.46	2.55	"	"	50.10	50.37

FIG. 1.

DEMONSTRATION.

R = Radius Circular Curve.
r = Radius Spiral Curve.
x = Horizontal Distances from point "A."
y = Vertical Distances from line A H.
K = Constant for each curve (determined by the length of Spiral and degree of circular curve.
I = Central Angle.
S = Spiral Angle.
D = Deflection Angle.
T = Tangent.

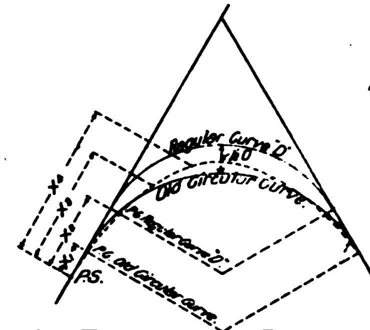
(1) $Y = \frac{x^3}{6K}$.
(2) $r = \frac{K}{x}$ At P.C.C. $r = R$, $x = x_4$ ∴ $K = Rx_4$.
(3) Tan. $D = \frac{y}{x}$.
(4) Tan. $S = \frac{x^2}{2K}$. (Tangent to curve at P.C.C.)
(5) $AK = \frac{2}{3}x_4$.
(6) $KF = \frac{1}{3}x_4$.
(7) $BD = \frac{1}{2}DE = \frac{1}{8}y_4$, $AD = x_4 - \frac{1}{2}x_4$.
(8) Tan. $AH = x_4 + (R + \frac{1}{4}y_4)$ tan $\frac{1}{2}I$.
(8) $R + \frac{1}{4}y_4 = (T - \frac{1}{2}x_4)$ Cot. $\frac{1}{2}I$.

FIG. 2.

NEW LINES.

(1) Locate the tangents and the regular curve "D."
(2) Set points on the tangent as indicated by x_1 x_2 x_3 x_4.
(3) From these points lay out the Transition Curve, by measuring at right angles to the tangent the ordinates Y_1 Y_2 Y_3 Y_4 with the aid of chords C_1 C_2 C_3 C_4.
(4) Beyond the point Y_4 the New or Transposed Curve is established by measuring in from the Regular Curve "D" the offset "O."

(1) For special application see supplemental sheets.
(2) Elev. here given for tracks 1 & 2. For other tracks and conditions see Book of Rules.



OLD TRACK.

FIG. 3.

Where the length of track is to be preserved to avoid closing expansion joints.
(1) Ascertain the degree of curvature and central angle of Old Circular Curve.
(2) From the external secant of this curve deduct 1½ times the offset "O".
(3) The result will be the external secant of the Regular Curve "D," which should be staked out as the basis for laying out the New Circular Curve & Transition Curve in the manner described for New Lines.
(4) Where the original alignment is irregular, the Engineer will be called upon to exercise his judgment and ingenuity in properly arriving at the desired results.

N.Y.C.& H.R.R.R.
STANDARD TRANSITION CURVE.
CUBIC PARABOLA.

[signature]
Chief Engineer.

DISCUSSION.

Mr. L. S. Rose (Cleveland, Cincinnati, Chicago & St. Louis):—In order to get the Committee's report before the Association, I think it would be well to have the conclusions read, and I therefore move that conclusion 1 be adopted.

The Vice-President:—Perhaps it will be best for the Secretary to read the conclusions one by one, and if anyone wishes to discuss them an opportunity will be given.

The Secretary:—"(1) That the formulas for the functions of the split switch proposed be approved as good practice."

Mr. Rose:—The formulas referred to are contained on pages 449, 450, 452, 453 and 454 of Bulletin 108.

Mr. W. C. Cushing (Pennsylvania Lines):—I would like to ask the chairman of the Committee if it is the intention to recommend as standard so many different lengths of switch rail, and, if so, what is the benefit to be derived from a recommendation of that kind?

Mr. Rose:—That refers to conclusion 2. It is the intention, however, to do that.

The Secretary:—"(2) That the properties of the frogs and switch rails given in the accompanying tables be approved as good practice."

Mr. Rose:—These tables are found on page 451. It was the intention of the Committee to prepare tables for frogs and switches which would meet the varied experience, which would be good for one railroad, but could be used by others, and for that reason the different lengths are given as shown here.

Mr. W. C. Cushing:—I think one of the chief values of the work of this Association is in harmonizing small differences like that into uniform practice. I think it helps the supplymen as well as ourselves not to have such minor differences in things of that kind. For that reason I am opposed to the recommendation.

Mr. C. H. Ewing (Philadelphia & Reading):—I thoroughly agree with Mr. Cushing in that matter, and would also still further object to the different lengths of frogs in that connection. I think that is unnecessary.

Mr. Rose:—I would ask Mr. Cushing and Mr. Ewing what ones they would omit.

Mr. W. C. Cushing:—I have no recommendation to make on that, Mr. President; I think as far as I am concerned, I would be prepared to try to have my practice conform with such recommendation as would be made by the Committee after a thorough consideration of the whole subject. At present we get along with two lengths of switches, 18 and 30 feet. I do not mean to argue those are the only and best lengths to use, but I believe that all of us can get along with at least three lengths of switches, and I do not think they need differ by two feet all the way up.

Mr. Rose:—The Committee has considered this quite thoroughly and had considerable discussion on the subject, and as a result prepared a table that anyone can use. It is not the intention of the Committee to recommend that all of these shall be used, but in canvassing the question we found it would be impossible to get all the members of this Association to agree on three lengths of switches. Any three we might take would not suit everyone; but the table can be used by any road that wants to use it after it is adopted.

Mr. W. C. Cushing:—Is it not possible to cut them down some, even if you have only four or five? I think as the work of this Association proceeds we have a revelation every once in awhile and find that where we could not do without a certain thing last year, we can do without it this year.

Mr. A. L. Kuehn (American Creosoting Company):—This table, as the Committee presents it, is essentially a formula and the Association in adopting it would simply adopt a method of computing switches and frogs, and would not by any means adopt all these lengths. There is a considerable difference in computing lengths of switches and frogs, and this formula is the best and would be used when two or three or four standards were adopted. The Association would simply put itself on record that it wanted the lengths computed in that way.

Mr. A. W. Thompson (Baltimore & Ohio):—As I look at this table, the figures as worked out are not theoretical all the way through.

Mr. S. S. Roberts (University of Illinois):—Not entirely theoretical all the way through for the reason that if the exact theoretical dimensions are adhered to, every part of every frog will be different and dimensions in fractions of inches will be obtained. We gave considerable thought to the preparation of the tables now presented, and tried, as far as possible, to reconcile our results to practice; not the practice of any one road, but considering the views of the Committee and all other information we could obtain, we feel that we have arrived at a compromise by the adoption and use of which no road will go very far wrong. The purpose of submitting this table of frogs and switch rails is simply to get an exact basis from which to revise the functions of turnouts that were submitted last year. The Board of Direction, as we understand it, requested us to revise that table, and that required a great mass of figures. The results of these figures are in the end based on the properties which are given to the frog and to the switch rail. The object in proposing this table is, therefore, to get the Association, if it does not agree with what we propose, to propose something definite to us so that next year, in carrying on the work, we can then revise the table as requested and get results that will meet with approval.

Mr. A. W. Thompson:—I think the argument is in line with the objection of Mr. Cushing, which I agree with, particularly since we are getting new sections of rail, and the stock of frogs and switches required to be kept on hand to meet so many sections of rail is get-

ting to the point where the stock is large and the interest alone on the money tied up in such stock amounts to a great amount of money. The managers of railroads are urging a reduction of the stock on hand, and if this table is worked out to meet something that the Association wants, I think the arguments of Mr. Cushing are good. I think all of us remember when the variations in frog angles, as shown on this table, were double, and there were many special frogs in addition to these, and for the very reason of the amount of material necessary to be kept on hand, we should consider a reduction in the number of frogs and switches recommended.

Mr. Roberts:—The Committee does not presume that every railroad will use every frog and every switch rail given in the tables. It is probable that any one particular road will have a certain standard frog for its main track and a certain standard frog for its sidetracks. Now we claim if any of the roads are using the properties of any of the frogs and the switches given in the tables as their standards, they will follow good practice; but we do not like to state that only two or three frogs and switch rails are the only standards we would recommend. The different roads by which I have been employed have all had three different frogs and switch rails termed standard; but the frogs and switch rails so designated were different on each road, and each road went through the whole gamut in their large terminals.

Mr. Rose:—This was brought forcibly to the Committee in answer to a circular sent out last year; out of forty or fifty replies hardly any two had the same frog and switch, and the adoption of this table does not commit the Association to all these as the practice that everyone should follow, but as the proper functions of frogs and switches of such numbers or lengths which can be used by the younger men.

Mr. W. C. Cushing:—I would like to correct the former speaker, in saying this length of switch rail has nothing to do with the switch lead. The switch lead calculation is an entirely different thing and the switch rail is fixed arbitrarily. It is a general principle, I think, that we all recognize, that no one wants any longer switch rail than is proper for the best construction of the track, and by reducing the number of frogs in use to as few as possible, we reduce the number to be carried in stock. It does, as Mr. Thompson has already said, reduce the stock of a railroad company very materially, and I do not know any better way that an engineer in charge of that kind of work on a railroad can benefit his company more than by giving very close attention to that very point and bringing down his stock. I have always considered that one of the great results to be accomplished by this Association was the harmonizing of the large differences in practice and in material used on the different railroads. It not only helps the railroad company, but it helps the supplyman, and our interests are mutual, and we should feel on that account that we are accomplishing something, and that is what we are working toward

constantly. If this table goes out in this way, one picks one thing and another picks another, and we are as widely apart as we are at the present time. Even on a large railroad system the engineers do not agree on these matters. Even on our own system we would probably have as large a table as this is, if we were not required to come together and agree on something, and I think this Committee can do the same thing and, working from proper principles, establish what seems to be a good length for these switches and say that that is what they recommend. The Association does not have to recommend it, if it does not want to, but it is the best judgment of the Committee, and the judgment of the Committee, when given in that way, carries weight. My remarks do not refer to the frogs, because that is a point in itself. The proper principles to establish the length of a frog are that the cutting of the flanges from angle bars should not be required, and they should fit the tie spacing. The Committee has recognized that principle in this list and their length of frogs may be all right. I have not gone into it sufficiently to say that it is not. I do know that our own length of frogs needs revision, and we have been postponing it largely on account of the work of this Committee in the hope that when we did make our next change we could begin to use the recommendations of the Association. Some of the arguments of the Committee indicate that railroad standards are inviolable, they cannot be changed, and that because the railroad companies have established them as standards, why, that ends it. It seems to me that is not a very forcible argument to use in a matter of this kind.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—It seems to me that the tables are hardly in proper form to be printed as a part of the Manual, because they involve a number of assumptions on which this Association has never taken action. These tables involve switch angles, lengths of frogs and lengths of switches, and the Association has not placed its stamp of approval as yet on any standards for any of these features. Furthermore, I may say that the maintenance of way committee of the New York Central Lines has given this question considerable study, with the result that it has been considered advisable and feasible to use three lengths of switch rails only as standard, and our aim, as an Association, should be to recommend standard practice with respect to this feature of railway work.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I would like to refer you to page 445 of the instructions of the Board of Direction to this Committee. Clause (a) reads as follows:

"(a) To revise the frog table submitted in 1908, and to extend the table to make it more nearly universal and to present a definite recommendation for the length of switch for each frog."

If this Committee has not complied with that instruction, I do not know how else they could have done it. It seems to me that this argument here to-night is for a new instruction to this Com-

mittee to be carried out next year, and I think it is not pertinent to this question.

Mr. W. M. Camp (Railway and Engineering Review):—I think this question ought to be settled here to-night, because precisely the same thing came up last year. Somebody objected to too many lengths of switches. Conclusion 2 reads: "That the properties of the frogs and switch rails given in the accompanying tables be approved as good practice." If by that the Committee means that they recommend all these lengths of switches, then I would agree with Mr. Cushing. I find switches in lengths of 10, 12, 15, 18, 20, 22, 24 and 30 ft. The only unusual lengths are the 18 and 22 ft. lengths. If the Committee intends to recommend all of these lengths, I would think that they have listed them too numerously; but if by these tables the Committee intends simply that if an engineer wishes to use any of these lengths he may turn to these tables and find the switch angle and the other data which pertain to that particular length of switch, then I see no objection to the tables as they stand. Does the Committee in conclusion 2 intend to recommend all of these lengths as good practice? Is that the intention of the Committee?

Mr. Rose:—Yes, sir.

Mr. Roberts:—I would like to say that one of the criticisms of this Committee last year was that the lengths of switch rails, as recommended, could not be cut from commercial lengths of rail without waste. We have tried to avoid this condition this year, and further we hope eventually to recommend leads that will contain between the heel of the switch rail and the point of the frog, commercial lengths of rail or such fraction thereof that the pieces cut will not be wasted. We selected 18 and 21 feet for switch rails so that an 18 and a 12 foot switch rail may be obtained from a 30-foot rail, and an 18 and a 15-foot from a 33-foot rail, and a 21 and a 12-foot switch rail from a 33-foot rail.

Mr. Camp:—You mean that 18 and 15 would go together and 22 and 11? That is, you could cut up a 33-foot rail so as to get 18 and 15 foot lengths or 22 and 11 foot lengths.

Mr. Roberts:—Yes, sir.

Mr. Camp:—If these tables would have the effect of increasing the variety in length of switches, I think it would be a good thing to cut out one or two of these lengths, as Mr. Cushing suggests. I would like to hear some expression from the members as to whether or not the tables might have that effect. Perhaps if the chair would call upon some manufacturer present we might get additional light on the question.

Mr. C. C. Wentworth (Norfolk & Western):—I move that the sense of the convention as a whole be given to the effect that there be only three lengths of switches and three lengths of frogs. I do not care to fix the lengths, but would leave that to the Committee.

Mr. A. L. Kuehn:—It seems to me an expression of that kind is

supplementary to this table. When we have adopted the table we have begun, and we can cut down to perhaps two lengths.

Mr. A. H. Rudd (Pennsylvania Railroad):—Mr. Chairman, you established a splendid precedent this afternoon by adopting the report of Committee No. 10 on rubber-covered wire. In that report there were tables of different sized wires, and each size required a certain insulation. Probably no one road will use all these wires. You have a table here of switch lengths, and if a certain length of switch is used, certain other things must be done. It does not necessarily follow that a road would use all those switch lengths. It seems to me the work of the Committee should not be thrown away, but that we should adopt the table and next year see if it is possible to come to some two or three lengths of frogs.

Mr. John V. Hanna (Kansas City Terminal):—I can appreciate the benefit to a road that is adopting standards of making the different length switch points as few in number as possible, but I do not see any particular advantage in having the frogs of the same length when they are of different angles. That would not affect your stock in any way. The number of frogs you keep in stock depends on the different angles of frogs you use for your work and not on the lengths. I think the proper thing to do is to have different lengths of frogs for different angles whenever there is anything to be gained by changing the lengths. Whenever, by changing the lengths, you can use your standard angle bars, or splices, without cutting, it is an advantage to do it. I do not know that the recommendation of a large number of switch points obligates any railroad to adopt all of them for its standards, and I can see considerable help to the engineers who have to figure these things out in having this information before them.

Mr. Roberts:—I think the point of the last speaker is well taken, and one of the ideas in having different lengths of frogs was to make the distance from the point to the toe of the frog as short as possible. In lengthening the wing rail of the frog we cut down the available tangent for the lead curve more rapidly than in any other way, and the shorter you can make the wing rail the lighter will be the lead curve and the better lead you will obtain. This is one of the reasons for choosing the frog dimensions recommended. We made the frogs, I believe, from No. 9 to No. 12 the same length from point to toe, so that as desired either spring frogs or rigid frogs might be made of the given length. We believe spring and rigid frogs of the same number should be the same length. Thus, if a spring frog in the track is broken and it is necessary to take it out of the track and the only frog on hand to replace it is a rigid frog, it will not be necessary to disturb the lead. Opposed to frogs of different number being of different length, this proposition has been advanced: "Suppose a frog is broken and you have not another frog of the same number to replace it. Your frogs are of different lengths; consequently you have got to tear up everything to put the frog in the track." In reply to

this my experience is, if frogs are of different angles, that is, of different numbers, and if you substitute one frog for another you have got to tear up the lead anyway in order to make any kind of a job.

The Vice-President:—We have the motion before the house, as I understand, to instruct the Committee to reduce these lengths to three in number. You will please confine your remarks to that motion as closely as you can. Do you wish to say anything, Mr. Cushing?

Mr. W. C. Cushing:—No, sir.

The Vice-President:—Is there any manufacturer present who would care to be heard from?

Mr. T. H. Gatlin (Southern Railway):—I wish to say that within the last year it has occurred to our railroad to use the lead curve and the formulas for the functions of the switches as worked up by the Committee, and in justice to them I would like to say that in special work the formulas for the functions made a very satisfactory fit in actual work in the field. Now it occurs to me that there are often times in the practice of all of us when this special switch work would become necessary. If we limit the labor of the Committee to reporting on only three lengths of switches and three lengths and angles of frogs, then the dissemination of complete information which we seek has been defeated, and it is greatly to be desired that the table be accepted as such for the information and government of those who wish to use it.

Mr. Ewing:—We have on our road frogs running from No. 2 to No. 20. We have absolutely no trouble in keeping the length of the switches down to four, and there is no reason why we could not get down to three. One member of the Committee has suggested the matter of keeping a certain length of frog for sidetracks and a certain length for main tracks. That would be a duplication at once. Material taken out of the main track could not be used in the sidetrack. We have three lengths of frogs. There is another feature in connection with it. We find frogs recommended that are 8 feet long. A great many of us would not permit a piece of rail to be placed in the track less than 12 feet in length, and yet we recommend a frog to be made of two pieces of rail for the main track when the total length is only 8 feet.

Mr. A. S. Baldwin (Illinois Central):—I think this motion is not apropos to the question before the house. This Committee has given a table and furnished a resolution to the effect that the properties of frogs and switch rails given in the table be approved as good practice. They have established in these tables a ratio between the angle, the length of frog and the switch point to be used with it. The question for us to decide now is, is this ratio correct? There is not a question before the house as to whether we should be restricted to certain lengths of frogs, properly speaking. We should first decide whether the ratio established in the table is correct. I fully concur in the idea that all of the tables should be preserved, because they have

information in them that is valuable, but at the same time it is proper for the Association to recommend as good practice that certain lengths of frogs and switches should be used in sidetracks.

Mr. Chas. S. Churchill (Norfolk & Western):—I will speak to the motion, as suggested; for twenty years we have used but three lengths of frogs for all sidings, generally only one, the other two being small angle frogs, the length being increased simply to cover the angle bar; and only two lengths of switches. I am heartily in accord with instructions being given to the Committee to reduce the number of frog lengths to three. There is an argument for the few standard lengths of frogs, namely, that trains will ride better over a long length than they will over a short length frog; and the substitution of a new frog for a broken frog is made simpler if the frogs are of the same length. This table is something to be used as giving the dimensions of a frog, or a switch that may be constructed by any road; and if the words "good practice" were omitted, and if it were described as a table of dimensions of frogs and switches for general information, I think there would not be any objection to these two conclusions. But I think when we lay before this Association something as being "good practice" it should embody dimensions of frogs and switches that roads generally use, not something that they might or would use, in case they see fit; and, therefore, multiply the dimensions of everyone of these articles and multiply the stock to be kept on hand, which we all complain about.

Mr. Camp:—I think it would be exceedingly good practice for any individual road to reduce the lengths of its switches to three standards, or even to two, if feasible, but if this motion prevails I think it will be difficult for the Committee to select any three certain lengths which would be suitable to the multitude of roads. If that were done the table may be less satisfactory than it is now. This motion has come up rather suddenly, this idea of placing upon the Committee the responsibility of selecting the three lengths to be used, and for that reason I would not like to see it carried.

Let us just consider, for a moment, the utility of these various switch lengths. A 10-ft. or 12-ft. switch is occasionally used on yard or industry tracks where there is necessity for a turnout of very sharp curvature. A length of 15 feet is, as we all know very well, in nearly universal use in this country and has been the standard length of split switch for more than a generation. Since higher speeds have come into practice, particularly where there is interlocking, it is desirable to have a switch point of smaller angle than corresponds to a 15-foot length, permitting faster speed through the turnout, and so the 20-foot length has come into use to a considerable extent. The 18-foot and 22-foot lengths might be considered variations from the 20-foot length, as, perhaps, fitting the turnout better, in the minds of some engineers; but they could, undoubtedly, be dispensed with without serious inconvenience to practice. Now the 24-foot and 30-foot lengths

are intended for switches at the end of double track, or at junctions or other points where a switchman or interlocking plant is located, so that trains may take the switch at good speed. Both of these lengths are largely in service and they are needed to suit conditions frequently found. In my mind, therefore, there are only two lengths in this list which could be considered superfluous in general practice, these being the 18-foot and 22-foot lengths; and it is a question in my mind whether we should take the time to quarrel over the propriety of leaving them out of the table. I think, however, that the majority of those who wish something rather sharper than the 15-foot point will go at once to 20 feet, and not stop at 18 feet.

Mr. Walter Loring Webb (Consulting Engineer):—Something has been said about the fixed ratio, or that there should be a fixed ratio, between the frog angle and the length of the switch rails. There is no necessity for any such fixed ratio. I think some of the speakers have discussed this matter as though what was wanted was that you simply select three frog angles, and say that all the work should be done with three frog angles. I do not think that is the idea. Keep all the frog angles that you have, but simply select three standard lengths for the point rails. When I was getting up my book on railroad construction ten years ago I adopted the same method. The methods given here are identical with what I used in my book over ten years ago. I got up my tables basing the lengths of the switch points and the frog lengths on some standards, which were then given out by some switch companies, and I selected three lengths of point switches, and on the basis of these three lengths and with the various frog angles I made out a set of tables which were almost identical with the tables given here, except that the lengths of the frogs, as given by these manufacturers, were slightly different from the lengths adopted by this Committee. But it would be easily practicable to select three lengths for the point switches and combining these with the lengths as they need to be, for as many frog angles as you can use, to get out standard dimensions for all these switches, and these will make switches which can be operated very easily, and yet at the same time it has the advantage of reducing the number of standards or the number of lengths of the point switch.

Mr. Wentworth:—Will Mr. Wendt please make his motion a little more precise.

Mr. Wendt:—It was not my intention to cut down the number of angles; I mean to keep them all. To put the motion more clearly, I would say that the Committee be requested to show in their table only three lengths of switch points and three lengths of frogs.

Mr. J. B. Jenkins (Baltimore & Ohio):—As I understand the motion it is to have three lengths of switches and also three lengths for all frogs. It seems to me the question of having three lengths of switches is somewhat different from that of having three lengths of frogs. While it may be possible for any road to limit itself to

three lengths for switch points, yet there are certain physical difficulties in the way of restricting the lengths of all frogs to three. I would, therefore, offer an amendment to the motion to eliminate the reference to the length of frogs, so that the two subjects can be considered separately.

Mr. Wentworth:—I did not mean to make No. 2 frogs 20 feet long—I meant to start with a No. 2 frog, say 15 feet long, and increase the length as required for frogs of higher number in order to get room for the angle bars.

Mr. W. D. Wheeler (Minneapolis & St. Louis):—On our system we could not confine ourselves to three lengths of frogs. We have turnouts on which a 15-foot frog, or even a 12-foot frog, would carry a car through the frog; there would be too much tangent through the frog. We have 33 and 35-degree curves, and our road could not confine itself to three lengths of frogs.

Mr. Churchill:—I do not like the argument to stand on the plea that one cannot do a thing. Some of us say that every day, on 30-degree curves, 25-degree curves and 10-degree curves, we are using frogs 15 feet long—the adjustment lies in the curving of the frog rails a short distance from the point.

Mr. Roberts:—When it comes to increasing our stock, we would have to keep twice as many frogs on hand if the last speaker's suggestions were adopted. Rights and lefts would then be necessary. The wing rails would either have to be curved by the manufacturer or by the track foreman in the field; and with due respect to the track foreman, for I am the foreman's friend, there are not many foremen who can curve a frog correctly, if they attempt it at all.

Mr. L. C. Fritch (Illinois Central):—This discussion only shows how impracticable it would be to select any number of switch rails and frogs that would be acceptable to all roads. Personally, I think the table of the Committee should stand, and let each road adopt as its standard the number of switch lengths and frog lengths it desires.

Mr. E. H. Lee (Chicago & Western Indiana):—As the last speaker has said, the course of the discussion very clearly shows that there can be no agreement on the question. The Association could as well try to get up a bill of specifications as to what kind of a wife a man should marry. Now, I will gamble that there are a certain number of men in this room who would swear by a red-headed woman, and there may be some who would like an Indian.

The Vice-President:—That is hardly the question—we had better confine ourselves to frogs and switches.

Mr. E. H. Lee:—If you will pardon me, I think an illustration is always germane to an argument or discussion. The statement of the gentleman that the table should stand, and that the selection should be left to each company, limiting it to two or three lengths, is perfectly proper and is a reasonable statement of the Committee's intention. I take the liberty of making this statement because I am not

on the Committee and, therefore, cannot be suspected of having an animus.

Mr. J. A. Atwood (Pittsburg & Lake Eric):—In order to bring this discussion to a conclusion I move an amendment to the motion, that conclusion 2 be made to read as follows: "That the properties of the frogs and switch rails given in accompanying tables be approved as good information;" and that the following also be added: "That the number of switch points and frogs used in general practice be reduced to as small a number as possible."

Mr. Wentworth:—I accept that.

(The question on the above amendment was put to vote and lost by a vote of 37 in favor to 38 opposed.)

The Vice-President:—The motion now before the house is to instruct the Committee to have in their tables only three lengths of frogs and only three lengths of switch points.

(Motion lost.)

Mr. W. H. Elliott (New York Central):—I move the adoption of conclusion 2.

Mr. M. L. Byers (Missouri Pacific):—Before that motion is put to a vote, I will ask if the Committee has considered the tie spacing in arriving at the lengths of frogs given in the table? It seems to me that the lengths given are such that some of the frogs would have the joints suspended, some of them would have them supported, or else the joints must be suspended in some cases and supported in others.

Mr. Rose:—The Committee considered the lengths of angle bars principally in figuring out the frogs.

(Motion carried.)

The Secretary:—"(3) That degree of curve be defined as the angle subtended by a 100 ft. chord.

"(4) That all curves be spiraled which would require 2 in. elevation for the highest possible speed."

Mr. E. R. Lewis (Michigan Central):—It occurs to me that the phrase "highest possible speed" used in conclusion 4, being a superlative, would be hard to define in practice. I ask if the Committee would consider "maximum" instead of "highest possible?"

Mr. Jenkins:—The objection to using the term "maximum speed" is that it might be taken to refer to the maximum schedule speed—for instance, a two-degree curve might be operated at a maximum speed of only 30 miles per hour, but it is not the intention to spiral only such curves as would have two inches elevation for that speed. Taken in connection with the recommended changes in the Manual and the discussion preceding, you will see that the object is to spiral curves which may actually have a much smaller elevation than two inches for the maximum schedule speed, but which would have an elevation of two inches for the highest speed that the line at that point is good for.

Mr. A. L. Kuehn:—It seems to me that is not a very good wording. We do not know what the highest possible speed is. You may increase the size of locomotives, and the highest possible speed may change. I want to ask the Committee how the two inches elevation was arrived at.

Mr. Jenkins:—The Committee will accept a change in the wording, making use of the word "permissible" instead of "possible."

The way the two inches was arrived at was in connection with the proposition to spiral the curve, not so much for schedule speed as for the degree of curve itself, that is to say, a 4-degree curve with eight inches elevation is good for a certain speed if the proper length of spiral is used. Now, if you put a shorter spiral on that curve, that shorter spiral will limit the speed to something lower than the limit set by the degree of curve itself; and if we make spirals part of the permanent alinement, which seems to be the practice of the majority of the roads then by putting in a shorter spiral, you would put a permanent restriction on the speed for that part of the line which is not called for by the maximum degree of curve. The two-inch elevation is arrived at in connection with the rate of runoff. With the rate of runoff proposed, the two inches elevation would give, for speeds of over 45 miles an hour, a uniform offset between the tangent and beginning of the circular curve of one-half an inch. The ordinate of the spiral at the middle point would be only a quarter of an inch, and at the end of the spiral would be two inches; in other words, the engine will travel over considerably more than half the spiral before the flanges of the wheel will strike the rail, and a spiral much shorter than that proposed would be, you might say, an imaginary spiral and not one that would have any direct influence on the riding qualities of the track.

Mr. A. L. Kuehn:—This conclusion involves a question of length of spiral—necessarily limits in a way the length of spiral. The thing which determines whether the spiral shall be used is the amount of offset. This varies with the length of the spiral. If that offset in a high-speed track is in the neighborhood of an inch, the curve should be spiraled. If it is not spiraled, the track will be a half-inch out of line, which at very high speeds is too much. It seems to me before adopting this conclusion we should determine on the proper length of spiral for different curves and different speeds.

Mr. Wheeler:—We have been spiraling curves of one degree. I do not think that is good practice. A two-degree curve should be spiraled and from that up. We are using a spiral of a three-degree curve, 60 miles, and use five inches elevation. The elevation is run at one-half inch to a 30-foot rail, making a spiral of 304 feet. On ballast work, on old line, with a cut on each end, and high fills in the center, I shorten the radius to three degrees and four minutes, putting half the offset on the outside of the center of the curve and one-fourth the offset at original curve points at ends of curves. On

ballast work, I maintain true grade at center of the track, and lower the inside rail 2½ inches, and give the outside rail a rise of 2½ inches. That, in my opinion, is as near taking care of the centrifugal force as you can get it. It was figured to 60 miles an hour. In riding in the engine you cannot tell the difference in the engine taking the curve from tangent track, showing positively that it is near a true line of centrifugal force, as near as you can get it.

Mr. Ewing:—I move the adoption of the Committee's conclusion 4, with the change of the word "possible" to "permissible."

Mr. L. C. Fritch:—The spiral should not be specified. It is impracticable to specify any uniformity as to the application of the spiral, because the location of the curve governs largely. A curve at the foot of the grade will require a spiral of different character from one at the top of the grade. Therefore, I think it would be impracticable to specify any uniformity in regard to the use of the spiral.

Mr. Wheeler:—In 42 miles of the road we constructed there are no two spirals alike. We have one at the foot of descending grades where we run 56 miles an hour with freight trains, and there is one at a summit where we never run faster than 45 miles. The engineer in the field should be governed by the conditions as he finds them.

Mr. A. L. Kuehn:—There is a desirable length of spiral, however, and that should be attained as nearly as possible.

(Mr. Ewing's motion carried.)

The Secretary—"(5) That wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to or exceeds one-half (½) in., and that it should then be corrected by closing in.

"(6) That paragraph (3), page 64, of the Manual under the heading of Maintenance of Line and Alinement, be withdrawn and the following version substituted:

"MAINTENANCE OF LINE AND ALINEMENT—RECOMMENDED PRACTICE.—(b) Adjustment of Curves with consideration as to Easement Curves:

"Easement curves should be used on all curves requiring an elevation of two inches or more.

"The choice of easement curves should be governed by the ultimate possibilities as to speed, with consideration as to probable revision of the worst features of alinement, rather than by existing schedule speed.

"On curves of 6° and over which are limiting curves as to speed, easement curves not less than 240 feet long should be used.

"On curves of less than 6° which are limiting curves as to speed, easement curves should be used whose length in feet is not less than 5⅓ times the speed in miles per hour calculated for an elevation of 8 inches.

"On curves which are not limiting curves as to speed, easement curves should be used whose length in feet, when the rail is elevated for the ultimate speed, will be not less than thirty times the elevation

in inches nor less than two-thirds the ultimate speed in miles per hour times the elevation in inches.

"Longer easement curves than the minimum lengths recommended may be used to advantage and often with increased convenience in their application, but any considerable increase in length is wholly unnecessary and should never be made without careful consideration as to the effect. The minimum length should be used in all cases where a greater length would adversely affect the degree of curve.

"Easement curves should be used between curves of different degree in the same way that they are used between curves and tangents.

"The curve elevation should be run out in the same distance as the length of easement curve, with no elevation on tangent and full elevation on the circular curve.

"Any form of easement curve is satisfactory in which the degree of curve increases with the distance; in which the rate of increase in degree of curve can readily be changed to suit each particular case, so that the length of easement curve shall be the same as the distance in which the outer rail is raised from zero to full elevation; which can be run in by deflection or offset, with chords of any desired length, and which is of the general type of Searles, Crandall, Holbrook, Talbot or cubic parabola."

Mr. Rose:—I move the adoption of conclusion 6, which carries with it the adoption of the matter just read by the Secretary.

(Motion carried.)

Mr. Rose:—I move the adoption of the following resolution, which appears on page 446: "Resolved, That the clear width of standard flangeway for all frogs and between main rails and guard rails be 1¾ inches, measured at the gage line, for all tracks of standard gage."

Mr. L. C. Fritch:—I want to ask the Committee whether they have had a conference with the M. C. B. committee on this subject, and whether the question was up for increasing the thickness of the wheel flanges.

Mr. Rose:—Our sub-committee held a meeting with the M. C. B. wheel committee, and there has been no change in the thickness of the flanges of the wheels over a year or two ago, but there was a change made in their standard gage, and they have corrected their inspection gage and mounting gage to take care of the discrepancies which were there. The word "mounting" on their standard has been changed to "inspection," and vice versa, and that makes a difference of one-eighth of an inch in the throatway of the wheels. In the standard inspection gage the distance from back to back of wheels at the gage point is five-eighths of an inch below a line drawn between the tops of the rails, which distance is 4 feet 5 3/32 of an inch. That is a minimum, and that leaves a clearance of seven-sixty-fourths of an inch on each side of the flange at the guard rail of the throat.

Mr. L. C. Fritch:—The reason I bring this up is there has been a good deal of discussion on the question of increasing the thickness

of wheel flanges, and one of the points brought up by the M. C. B. Association was that it would be difficult to get the Maintenance of Way Association to increase the flangeway. We all know that an increase of one-eighth inch in thickness of the flange will reduce broken flanges. I think, therefore, before we adopt this resolution we should be sure that question has been threshed out, because if we do not, and establish this standard, some flangeways now 1⅞, might be changed, and would have to be changed back again.

Mr. Camp:—The American Railway Association has recently passed upon this question of the standard width of flangeway, and I think they took into consideration the increased width of wheel flanges.

Mr. Rose:—The question of the thickness of the flange is a pretty serious one. You cannot make it any thicker without striking the point of the frog. The M. C. B. Association recommends that you should have 1⅞-inch flangeway, but with a 1⅞-inch guard rail distance you cannot guard the frog point. They have not only drawn the flange high, but made it thicker, and the only way we can help them is to maintain the 1¾-inch flangeway at the guard rail.

Mr. L. C. Fritch:—I cannot see how the frog point will be changed by an increase in the width of the flange of the wheel if the thickness is added to the back of the wheel.

Mr. A. L. Kuehn:—The Big Four for three years used 1⅞-inch flangeway, and has not had any trouble with wheels striking the frog points. The cast-iron wheel flanges to-day are not strong enough, and we must make provision for either strengthening these flanges or put ourselves in the way of forcing a change in wheel construction, that is, forcing a change from cast-iron wheel to a steel-tired wheel, which will mean at least three or four times the cost on wheels. It is practicable to use a 1⅞-inch flangeway; I know that from personal experience. It appears there was a mistake made by the M. C. B. Association in the drawings of their gages. These gages have been used for some years. Wheels have been made to fit these gages, and wheels which are so made are so narrow inside that they will just pass the 1⅞-inch flangeway. A new guard rail in which the gage is ⅛-inch wide, which will occur at least five times out of ten, will require forcing the guard rail on the frog, as well as the guard rail on the main rail.

Mr. L. R. Clausen (Chicago, Milwaukee & St. Paul):—I am under the impression that an investigation either by the M. C. B. Association or the American Railway Association determined that the breaking of the flanges was due to the starting of miniature cracks in chilled surface of the wheel, probably due to breaking. I think it would not be advisable to establish a flangeway as standard at the present time until that question has been gone into thoroughly to determine whether it is necessary to increase the flange.

Mr. A. W. Thompson:—The point Mr. Fritch brought out is being discussed in the M. C. B. Association at this time. The mistake

Mr. Kuehn refers to is this: I understood in making their gages some years ago they decided on a standard gage. None of the railroads followed the gage accurately. They changed the gages and got additional wear out of the flange, and the question is now up before the M. C. B. Association to increase the thickness of the flange one-eighth of an inch, the metal to be placed on the back of the flange.

Mr. Ewing:—The Committee has illustrated this matter correctly and stated the facts. As I understand it the M. C. B. Association did within the past year increase slightly the thickness of the flange. They concluded that greater strength was needed at a point slightly above the tread of the wheel. They have taken into consideration a 1¾-inch throat and reinforced their flangeway to meet that condition. I also believe that the American Railway Association, at its last meeting, definitely decided that 1¾-inch was the proper flangeway.

Mr. Churchill:—I think there is still some discussion to be had on this question, and that this matter should be held over another year, or else the flangeway of guard rails should be increased. I wish to amend the resolution of the Committee to this effect:

"That the clear width of standard flangeway used for all frogs be 1¾ inches, and between rails and guard rails be 1⅞ inches."

The argument for this is given by the gentleman who spoke a few minutes ago, that 1⅞ inches is in use. When 1¾ inches only is used there is a great strain on the flanges of wheels. The drawings as presented show, I believe, only three-thirty-seconds of an inch clearance between a correctly set guard rail and a minimum set wheel flange. That is entirely too close working. Further, the plan in the Committee's report according to some data I sent to the Committee, in a personal discussion, does not show correctly the facts, there is not the interference as pictured thereon between the fillet of the wheel and the point of the frog, or stock rail.

Mr. L. C. Fritch:—In seconding Mr. Churchill's motion, I would say that there is too much uncertainty about the question for us to hastily decide on 1¾-inch flangeway. I am not so sure but that the American Railway Assocation have not decided that question definitely. If my memory serves me, a circular was sent out by the American Railway Association last year recommending an increase of one-eighth inch in the thickness of wheel flanges. I am quite sure they have not decided on 1¾-inch as the standard flangeway. I think Mr. Churchill's amendment is proper. The track has a tendency to get out of gage. As the gage widens there is more necessity for more flangeway.

Mr. Rose:—The widening of the gage is intended to be taken care of in the resolution. It is 1¾-inch for standard gage of 4 feet 8½ inches. The Committee would not feel so badly about Mr. Churchill's motion if he would turn it around and make the width of the flangeway at the guard rail 1¾, and on the frog 1⅞ inches.

Mr. Camp:—I can tell you certainly that the American Railway Association did express itself in favor of a 1¾-inch flangeway within

the past year. If we adopt this 1¾-inch flangeway, it does not change present practice. That width has been standard since 1886.

Mr. Wentworth:—The reason for holding to the 1¾-inch flangeway through the frog is in order to lessen the jump which the wheel has to make over the other flangeway going through the same frog. These frog flangeways should be kept 1¾ inches, if we can do so; I think for a while we can. Perhaps later we cannot, but I am sure that a 1⅞-inch flangeway at the guard rail is in line with what we will have to do pretty soon.

Mr. W. C. Cushing:—After thorough investigation the American Railway Association adopted 1¾-inch flangeway, as Mr. Camp stated, but on their attention being called to it, they were not satisfied with the language in which it was expressed, and they have asked this Association to formulate a recommendation in better language, which communication was turned over to the chairman of this Committee, and he had that before him in making this recommendation, if I am not mistaken.

(Mr. Churchill's motion was lost; the motion to adopt the resolution carried.)

The Secretary:—"Wide gage, due to worn rail, within the safe limits of wear, need not be corrected until the excess over the gage is equal to or exceeds one-half (½) in., and should then be corrected by closing in.

"Your Committee recommends that the following paragraph be substituted for the one now appearing on page 64 of the Manual of 1907 (the change consisting of the substitution of one-half (½) in. for "three-eighths (⅜) in.):"

"That within proper limits a slight variation of the gage from standard is not seriously objectionable, providing the variation is uniform and constant over long distances. Under ordinary conditions it is not necessary to regage track if the increase in gage has not amounted to more than one-half (½) in., provided such increase is uniform."

(On motion the recommendation was adopted.)

Mr. Rose:—The Committee calls attention to the specifications for frogs and switches given on pages 455-458 of Bulletin 108. The object of presenting these specifications was to get criticisms, and it is the intention of the Committee next year to submit specifications for adoption. The Committee has taken a lot of the Association's time, and we would ask that these specifications be accepted as a progress report.

Mr. Gatlin:—I suggest in the first paragraph, where it provides that the company shall be notified of any omissions in the drawings or specifications, that the following be added at the end of the sentence: "Before proceeding further with the construction of the work."

The Vice-President:—The Committee will give consideration to

that suggestion in their revision of the specifications for final approval.

(Motion carried.)

Mr. W. C. Cushing:—I ask the Committee if they have anything to say in reference to their recommendations on page 446 under "(b) Report on facing point switches for high speeds with a continuous main line rail." The Committee says it reaffirms its report of last year.

Mr. Rose:—That is the Committee's report. The Committee was asked to reconsider its report on switches for continuous main line rail, and this is the report it submits.

Mr. W. C. Cushing:—Is it not proper to ask for some action?

Mr. Rose:—The Committee would like to have its report adopted. There were no conclusions that followed this subject. There is no intention to place this portion of it in the Manual, and I would move that the Committee be discharged on this question.

Mr. W. C. Cushing:—I judge the Association must have had some reason for asking the Committee to reconsider it. It seems strange to drop it right there and do nothing more in regard to it.

Mr. Rose:—The Committee did study the matter and reaffirm its report of last year.

Mr. McDonald:—I suggest that the reference to the report of the Committee of last year would be in order.

Mr. L. C. Fritch:—I have last year's report, page 388, in reference to the relative merits of split switches, etc. The matter is as follows:

"In reference to the relative merits of split switches and switches which provide continuous main track rails, a few replies were received to questions asked upon this subject in the circular. These answers confirm the opinion of your Committee.

"A practical switch fulfilling the requirements of continuous main track rails has been in use for a number of years. This form of switch is going out of use; its first cost is about three times the cost of the split switch, and it has not proved to have afforded any greater safety. On account of the necessary elevation of the switch above the main track rails, there is liability of damage to equipment. The speed of trains must be the minimum when using turnouts equipped with lifting switches. On account of its not being suitable for all points a double standard is required. Trains are frequently parted when using these switches on account of the heavy grade upon the switch rails. It is practically impossible to keep the wing rail on spring frogs in proper position with continuous main track at the switch."

The Vice-President:—It was not accepted by the convention last year. We are hardly in position this year to vote on it.

Mr. W. C. Cushing:—I move that the report be accepted and the subject dropped.

(Motion carried.)

Mr. Roberts:—In regard to completing the table of switch leads, I ask how we shall do it. In figuring in accordance with any exact formulas you obtain leads which will give such lengths of rail between the toe of the frog and the heel of the switch rail that it will be necessary to cut the rail and make scrap. By modifying the theoretical lead very slightly, that is, by making it a fraction shorter or a fraction longer than the absolutely correct theoretical lead, you obtain a lead which differs in curvature and length only slightly from the theoretical one, and in which you can use commercial lengths of rail or both pieces if you cut the rail. The opinions advanced to us in regard to such leads are varying. Some insist that we shall stick absolutely to the theoretical lead, and others say we should adopt the practical or modified lead. Before computing a table and completing it, the Committee would like to know what is the wish of the Association. Shall we use the absolutely correct theoretical lead or shall we use the practical lead?

Mr. Ewing:—In order to get the matter before the convention, and as information for the Committee, I move the Committee prepare a table of practical leads conforming closely to the theoretical.

(Motion carried.)

Mr. Wendt:—Before we pass on this report finally, will the Committee kindly indicate what should be included in the Manual under the head of conclusion 1, page 447.

Mr. Rose:—The tables on pages 451, 452, 453 and 454.

The Vice-President:—This concludes the business of the Committee and it can consider itself excused with the thanks of the Association.

Mr. S. S. Roberts (University of Illinois—by letter):—The formulas for determining switch leads, as given in Bulletin 108 in the report of the Track Committee, are believed by the writer to be as simple in form as it is possible to reduce exact formulas for the functions of a turnout where the split switch is used.

Substituting in the formulas mentioned the properties of the standard switch rails and stiff frogs of one of the principal railroads of the South; neglecting the actual thickness of the point of the switch rail and working to the theoretical point of frog, the following table of switch leads and lead curves is obtained.

Under the assumptions made, to construct a turnout in accordance with the length of lead given in table No. 1, will give a theoretically correct turnout.

However, whether or not the length of the curved lead rail is calculated and adhered to, it will be necessary to cut rails and to make scrap rail whenever a turnout is so constructed.

The labor lost in cutting the rail, handling and shipping scrap, as well as the loss due to the difference between the cost of the new rail and its scrap value, caused the particular road the writer has in mind

to adopt for its standard turnouts a slight modification of the purely theoretical leads given in table No. 1.

These modified leads may be termed practical leads, and they are slightly longer or shorter than the theoretical leads. They are so chosen that the rails between the frog and the switch rail, for both the straight and curved rails, are either of commercial lengths or such fraction thereof that, where cutting is necessary, both pieces of the rail may be used, obtaining at once both a minimum of cutting and of scrap.

The difference in length of the theoretica' and practical leads and the difference in the degree of the lead curves is small, as shown by table No. 2.

By using the same length of rails in the straight and curved lead rails, as outlined in table No. 2, it is not always possible to maintain the condition that the points of the switch rails sha'l be directly opposite.

This seems to be the chief criticism of the practical leads.

Opposed to this criticism it is held:

(a) As the number of the frog increases, the amount the points of the switch rails lack of being directly opposite decreases.

(b) The error may be decreased, if not overcome, by laying the straight portion of the lead with tight joints and the curved portion with open joints.

(c) The slight difference in location of the points of the switch rails makes no appreciable error in the adjustments and throw of the points.

(d) As only one side of the lead is in service at one time, and as the switch rods and rails do not form a figure of stability, the practical leads are as safe as the theoretical leads.

For six years the writer was employed by the Southern road, first mentioned, that used practical leads about as given in tab'e No. 2. During that time he was engaged in the construction of yards and terminals, and in the maintenance of way department as division engineer, and roadmaster, where he had opportunity of closely observing the performance of the switches. From his observation of the practical leads in service, he believes them equally as easy riding and of as finished appearance as the theoretical lead and more economical both to construct and to maintain.

If it may be assumed that the practical lead is good practice, then it would appear useless to laboriously figure through the exact formulas submitted by the Track Committee in order to determine the length of the lead and the degree of the lead curve. For, by giving the switch rail a number, as we do the frog, we obtain: The number of the switch rail equals

$$N' = \frac{\text{Length switch rail in feet}}{\text{Heel distance in inches}} \times 12,$$

TABLE No. 1.

Theorectical Switch Leads.

N=Frog No.	F=Frog Angle.	W=Distance Point to Toe of Frog.	K=Distance Point to Heel of Frog.	S=Length of Switch Rail.	H=Heel Distance.	A=Switch Angle.	L=Length of Lead.	D=Degree of Lead Curve.
4	14° 15′	3′ 00″	3′ 00″	10′ 00″	5″	2° 23′ 17″	37.20	50° 51′
5	11° 25′	3′ 00″	3′ 00″	10′ 00″	5″	2° 23′ 17″	43.48	30° 01′
6	9° 32′	4′ 04″	7′ 10″	10′ 00″	5″	2° 23′ 17″	48.49	21° 03′
7	8° 10′	4′ 04″	7′ 10″	12′ 00″	5″	1° 59′ 24″	57.58	15° 00′
8	7° 09′	4′ 04″	7′ 10″	15′ 00″	5″	1° 35′ 31″	68.38	11° 21′
9	6° 22′	4′ 04″	7′ 10″	15′ 00″	5″	1° 35′ 31″	74.08	8° 43′
9½	6° 02′	4′ 04″	7′ 10″	16′ 06″	5″	1° 26′ 52″	79.48	7° 50′
10	5° 44′	4′ 04″	7′ 10″	16′ 06″	5″	1° 26′ 52″	82.30	6° 59′
12	4° 46′	6′ 00″	11′ 00″	18′ 00″	5″	1° 19′ 35″	95.24	4° 50′
15	3° 49′	7′ 06″	12′ 06″	20′ 00″	5″	1° 11′ 39″	114.14	3° 02′

TABLE No. 2.

Theoretical and Practical Switch Leads.

N=Frog No.	THEORETICAL LEADS.		PRACTICAL LEADS.		
	L=Length of Lead.	D=Degree of Lead Curve.	L=Length of Lead.	Degree of Lead Curve.	Rails required.
4	37.20	50° 51′	37.00	50° 57′	2-24
5	43.48	30° 01′	43.00	31° 16′	2-30
6	48.49	21° 03′	48.33	21° 19′	2-24 2-10
7	57.58	15° 00′	58.33	15° 10′	2-30 2-12
8	68.38	11° 21′	70.33	11° 38′	2-27 2-24
9	74.08	8° 43′	76.33	8° 57′	2-30 2-27
9½	79.48	7° 50′	80.83	7° 51′	2-33 2-27
10	82.30	6° 59′	83.83	7° 07′	2-33 2-30
12	95.24	4° 50′	96.00	4° 50′	6-24
15	114.14	3° 02′	114.50	3° 02′	2-33 4-27

and from a simple figure and by an equally simple proof we obtain the following approximate formula for the length of the switch lead:

$$L = (S + W) + 2\left[\frac{N'(4.7\,N - W) - SN}{N + N'}\right] \qquad \text{(1)}$$

A comparison of the results obtained by the approximate and exact formulas is shown in table No. 3 following:

TABLE No. 3.

Comparison of Switch Leads, as Given by the Exact and Approximate Formulas.

N=Frog No.	LENGTH OF THEORETICAL LEADS.	
	Exact.	Approximate.
4	37.20	37.24
5	43.48	43.48
6	48.49	48.52
7	57.58	57.55
8	68.38	68.31
9	74.08	74.09
9½	79.48	79.48
10	82.30	82.31
12	95.24	95.06
15	114.14	113.98

From table No. 3 it is evident the approximate formula is sufficiently accurate to form a basis for selecting a practical lead.

Having selected a practical lead, which call L′, and calling the lead given by formula (1) L, we know

When $L' < L$ there must be a short piece of tangent adjacent to the toe of the frog.

When $L' > L$ there must be a short piece of tangent adjacent to the heel of the switch rail.

When $L' < L$ the distance from the heel of the switch rail to the point of intersection of the switch rail produced with the frog produced is the tangent distance of the lead curve.

When $L' > L$ the distance from the toe of the frog to the above point of intersection is the tangent to the lead curve.

To determine the degree of the lead curve of the practical lead:

Let $x =$ the distance from the toe of the frog to the point of intersection of the extension of the wing rail and switch rail.

Let $y =$ the distance from the heel of the switch rail to the said point of intersection.

Let $F =$ the frog angle, $a =$ the switch angle, $w =$ distance from point to toe of frog, $S =$ length of the switch rail and $G =$ gage; then

$$x = \frac{G \cos a - L' \sin a}{\sin (F - a)} - W \quad \text{.............................} \quad (2)$$

and

$$y = \frac{L' \sin F - G \cos F}{\sin (F - a)} - S \quad \text{.............................} \quad (3)$$

When $L' < L$, then $x > y$ and $y =$ tangent distance to lead curve. The length of tangent adjacent to the toe of the frog and between it and the P.T. of the lead curve is

$$t_f = (x - y) = \frac{G \cos \frac{1}{2}(F + a) - L' \sin \frac{1}{2}(F + a)}{\sin \frac{1}{2}(F - a)} + (S - W) \quad (3a)$$

When $L' > L$, then $y > x$ and $x =$ tangent distance to lead curve. The length of tangent adjacent to the heel of the switch rail and between it and the P.C. of the lead curve is

$$t_s = (y - x) = \frac{L' \sin \frac{1}{2}(F + a) - G \cos \frac{1}{2}(F + a)}{\sin \frac{1}{2}(F - a)} - (S - W) \quad (2a)$$

$$R = T \cot \tfrac{1}{2}(F - a) - \frac{G}{2} = y \cot \tfrac{1}{2}(F - a) - \frac{G}{2} \quad \text{..............} \quad (3b)$$

or

$$= x \cot \tfrac{1}{2}(F - a) - \frac{G}{2} \quad \text{...................................} \quad (2b)$$

The offsets from the gage side of outer rail of lead curve to the gauge side of the rail of the principal track are:

$$Y = \left[H + (R + \frac{G}{2}) \cos a\right] - \left(R + \frac{G}{2}\right) \cos (\mu + a) \quad \text{..........} \quad (3c)$$

or

$$Y = \left[(S + t_s) \sin a + (R + \frac{G}{2}) \cos a\right] - (R + \frac{G}{2}) \cos (\mu + a) \quad (2c)$$

The distance measured on the rail of the principal track from a point directly opposite the point of the switch rail of the straight portion of the lead to the foot of the offset Y is

$$X = \left[S - (R + \frac{G}{2}) \sin a\right] + (R + \frac{G}{2}) \sin (\mu + a) \quad \text{..............} \quad (3d)$$

or

$$X = \left[(S + t_s) - (R + \frac{G}{2}) \sin a\right] + (R + \frac{G}{2}) \sin (\mu + a) \quad \text{.....} \quad (2d)$$

Throughout the above formulas the notation used is that used in the report of the Track Committee.

If it is desired to determine approximately the degree of the lead curve, the following formula may be used in connection with formula (1):

$$R = \frac{N'(4.7\,N - W) - SN}{N + N'} \times \frac{4\,NN' + 1}{2(N' - N)}$$

$$D = \frac{5730}{R}.$$

From the writer's experience and the above comparisons he concludes:

(1) That the use of practical leads is good practice.

(2) That the approximate formula (1), herein above given, is sufficiently accurate for a basis from which to select a practical lead.

(3) That, having selected a practical lead by formula (1) or by any exact formula, the determination of the remaining functions of the turnout by formulas (2) to (2d), or by (3) to (3d), herein above given, is good practice.

The writer camot claim sufficient familiarity with the transactions of the Association to state positively that the above points have never been discussed in them. However, being of the opinion that the points set forth herein have not been so discussed, he submits this paper to obtain the criticisms and views of the Association thereon.

Mr. A. C. Dennis (Canadian Pacific—by letter):—The usual standard elevation for outer rail on curves may be calculated as follows: Elevation in inches equals square of the speed in miles per hour divided by 1,600, multiplied by degree of curve. One-inch elevation corresponds to a speed of 40 miles per hour on a one-degree curve, and varies as the square of the speed and directly as the degree.

Curves may be passed at a speed corresponding to 3 in. more elevation or 6 in. less elevation than the speed for which the curve was adjusted without producing a feeling of discomfort or danger. They are safely passed at speeds where the centrifugal force and elevation are much more out of balance. A 4-degree curve elevated 8 in., which corresponds to about 56.5 miles per hour, can be run comfortably at 66.5 miles per hour, less than 20 per cent. increase speed being equivalent to 3 inches more elevation, or can be run comfortably at about 28 miles per hour corresponding to 6 in. less elevation. This curve is safe but not comfortable at 70 miles per hour, for which speed it is under-elevated 4¼ in., or at 1 mile per hour, at which speed it is over-elevated 8 in. A 4-degree curve elevated 1 in. for 20 miles per hour is comfortable at 40 miles per hour, which corresponds to 100 per cent. increase in speed.

The excess speed comfortable or safe beyond that for which curve is elevated is properly measured by the additional elevation required. The method by percentage of additional speed is an incorrect standard, since the percentage is not constant, but varies inversely with the

speed. Extreme elevation of 7 or 8 in. permits only a slight percentage of increase in speed over that for 4 or 5 in. elevation and is uncomfortable at low speeds or for stop, increases curve resistance greatly for slow trains, facilitates the destruction of rail and ties under slow traffic, and should not be used on long ruling grades for single-track lines.

Elevation should be runoff at rate of a ½-in. per 33 ft., or 1 in. per 33 ft. Trackmen can understand and apply a rate of runoff given them as a "notch to the joint," while they are confused by a rate given them in other terms. The inch per 66 ft. is preferable but not worth much expenditure over the rate of an inch per 33 ft. The short-rate runoff rides as easy as the circle for moderate speeds.

The spiral should be of the same length as the runoff, which makes spiral depend on the elevation and only indirectly on the degree. The elevation increasing rapidly with speed, carries with it an increasing length of spiral corresponding to the same speed as the elevation is designed for. Elevation with spiral to correspond should be determined for each curve when locating the line. Probable speed can readily be approximated by one familiar with such work from a study of the profile for any class of train. Should the elevation of any curve have to be changed so that the spiral length does not correspond to the usual rate of runoff, it would only result in some inconvenience to the trackmen. It is better to be sometimes wrong in working to the wrong elevation, than to be generally wrong by using the same spiral for the same degree of curve regardless of the probable variation in its elevation.

For many years the writer has used a spiral, practically the cubic parabola, which does not require fieldbooks or tables to determine the deflections and can be any length and fit any circle. This spiral is based on chord lengths, each ¼, 1-6 or other equal part of the spiral length. The deflections for these points for all lengths of spiral joining any curve whatever are always a fixed proportion of the spiral angle. The deflections for the four-point spiral going on are 1^2, 2^2, 3^2, 4^2 or 1, 4, 9 and 16 times the deflection unit. The deflection for the last point is one-third spiral angle = 16 deflection units. One deflection unit is equal, therefore, to the spiral angle divided by 48. The deflections from beginning of spiral are 1, 4, 9 and 16 times this unit for all spiral lengths and angles. The deflections going off are those for the circle produced less the above, or 11, 20, 27 and 32 times this deflection unit for the four quarter points of this spiral. The deflections for a six-point spiral are similarly 1, 4, 9, 16, 25 and 36 times the deflection unit going on and 17, 32, 45, 56, 65 and 72 times going off. The spiral unit is one-third the spiral angle divided by the square of the number of equal parts of spiral length. For the six-point spiral, it is spiral angle divided by 108. The offset or shift from tangent of the spiral to the circle produced to a parallel tangent is

length of spiral in stations, multiplied by 1.75 ft. by deflection in degrees for center of spiral.

The many easily figured characteristics of this curve commend it for platting and ease in running in difficult country, it being to one familiar with it about as easy as the circle. The difference from the true cubic parabola is immaterial within usual spiral limits and it is adjustable exactly to any length of spiral and is exactly tangent to the circle.

Mr. J. B. Jenkins (Baltimore & Ohio—by letter):—The rule given by Mr. Dennis for calculating elevation, expressed in the same form of formula as that given in the Manual of Recommended Practice, is $E = .000625\,D\,V^2$, as against the adopted formula $E = .00066\,D\,V^2$, which is approximately the correct theoretical elevation required to maintain the resultant of forces in a line normal to the plane of the track.

In the adopted formula E is measured at the gage line, while track levels are so constructed as to measure the elevation at the outer edge of the rail. If E is taken as the measure indicated by the ordinary track level, the factor would be increased to about .00069.

The elevation proposed by Mr. Dennis is in line with the contention of some engineers that the elevation should be kept low in order to maintain a constant pressure against the outer rail; but is this not already accomplished to a sufficient degree by frictional resistance to the turning of the truck? The question is an old one, but always one of interest.

The rule proposed by Mr. Dennis has the arithmetical advantage of giving an elevation which is expressed exactly in even sixteenths of an inch when the curve is of an even degree and the speed is a multiple of ten.

The opinion of Mr. Dennis as to the amount which the calculated speed may be exceeded without discomfort practically coincides with the opinion of the Committee on Track, Bulletin 108, page 469: "It seems evident that if the theoretical speed is exceeded more than 15 or 20 per cent. on a curve having 8-in. elevation, or if the required elevation exceeds the actual elevation by more than 2½ to 3½ in., there would be discomfort to a considerable proportion of the passengers."

In answer to the statement by Mr. Dennis that elevation should be run off at a rate of a half-in. per 33 ft., or one in. per 33 ft., in order that the trackman may change his track level "a notch to the joint," the writer begs to submit that there are more 30-ft. than 33-ft. rails in track to-day; that our Association recommends a *minimum* standard length of 33 ft.; that the length of rail is governed mainly by length of gondola car; that 36-ft. or 40-ft. rails may soon be the rule rather than the exception, and that 60-ft. rails are already used to a considerable extent.

Should we choose a standard runoff that would compel us to change our alinement, not only when the addition of a flyer or the

diversion of express trains to another route calls for a radical change in elevation, but whenever we replace light or worn-out rails with rails of different length?

Should we choose a standard that would require one alinement for a track on ascending grade and another alinement for a parallel track on a descending grade? A four-track line on a ruling gradient would necessarily require different elevations for each of the four tracks. Conditions might require an elevation of ¼-inch for the ascending freight track, 4¼ in. for the ascending passenger, 2⅜ in. for the descending freight and 8 in. for the descending passenger track, these being the respective elevations for a 4-degree curve for 10, 40, 30 and 55 miles per hour.

Every track foreman carries, or should carry, a tape line. If the required elevation is 4¾ in. and the length of spiral is 270 ft., there are not many foremen who could not ascertain that this means ¼-in. in 14.2 ft.; this information should, however, be painted on the elevation post.

It is true that the spiral should be of the same length as the runoff, but the rule should be stated conversely—that the runoff should be of the same length as the spiral. The writer considers that it is usually impossible to determine, at the time a line is located, the exact speed at which the fastest trains will be scheduled after the road is put in operation, as there are so many factors, aside from alinement and profile, which govern the operated speed of trains. A proper study of the alinement and gradients will determine, however, the maximum speed for all parts of the line, and the results of this examination should be indicated on a speed profile; curves should then be spiraled for the maximum speeds thus determined.

In rough country the expected requirements of traffic usually lead to the adoption of a maximum degree of curve for a new line and topographic conditions usually require the repeated use of the maximum curve. When there is no fixed maximum degree of curve or when the topography permits lighter curves than the maximum being used, the best practice is to group the curves, making free use of the maximum curve required by topography in one locality, while making liberal expenditures to avoid exceeding the lighter curves generally permitted by topography in another locality.

In the above cases the maximum degree of curve (either locally or consecutively considered) will usually govern the maximum speed for which the curves should be spiraled.

Supposing a line has been located with maximum curves of 4 degrees over one portion and 6 degrees over another and the whole line spiraled for a speed of 40 miles per hour, the highest expected speed; then, in the event of an extension of the line, consolidation, or traffic agreement, by which more important points would be reached that would necessitate running faster trains, the change in elevation would result in something much more serious than some inconvenience to

the trackmen; it would result in discomfort and annoyance to passengers, owing to too short runoffs, where there would be no discomfort on the circular curves and would be a permanent fault in alinement; but if the expected speed of 40 miles per hour should not be exceeded, then, in all probability, much money has been wasted in building a line with 4-degree curves, where a line with sharper curves, meeting all requirements of traffic, could have been built at much less cost.

Thus, for the character of lines mentioned above, the question of spiraling resolves itself mainly into one of the degree of curve which limits the speed.

But there are many lines and portions of lines in which topography does not govern the maximum degree of curve, in which case degree of curve is not in any way related to the maximum speed, but is kept as low as practicable in order to minimize frictional resistance on slow-moving freight trains. On such lines and portions of lines the length of spiral should be governed by the highest speed for which the line is adapted, as determined by a study of the profile.

The recommendation for spiraling curves which are not limiting curves as to speed, adopted as part of the Manual at the last convention, covers, in the opinion of the writer, all such special conditions as a curve at the summit of a heavy grade, curves within yard limits, and at junctions and crossings of other roads; where no spiral is possible the elevation should be restricted to about two in. at the point of curve, if comfortable riding is to be assured, and a proper limit placed on the speed.

Years ago the writer used the identical method of running spirals without tables mentioned by Mr. Dennis, with the single exception of the method of obtaining the offset or shift. The method and results were found to be quite satisfactory for the ordinary spirals used at that time for spiraling old tracks, but were found to be inaccurate and unsuited for spirals of large central angle.

The properties of the spiral mentioned by Mr. Dennis are just as true now as they were then and should be kept in mind by all transitmen. But the errors resulting from such approximation are not always negligible and there is a real necessity for formulas which will not only eliminate all appreciable errors, but will be of simple trigonometrical form and easy of solution.

The writer does not consider the amendment to the Manual of Recommended Practice adopted at the last convention to be unassailable or that it is necessarily the best practice; that can be determined only by careful and long-continued trial. But it is at least a safe rule and will serve to correct three common faults in the present widely diverging practice:

(1) The haphazard method of re-running track centers and changing alinement every two or three years in order to accommodate varying speeds and varying ideas in regard to the proper length of

spirals; sometimes sharpening curves and lengthening spirals and again lightening curves and shortening spirals; constantly shifting the track away from the old and solid roadbed; destroying the value of all previous records of alinement and frequently keeping no record of the new.

(2) Penalizing the alinement by increasing degree of curve to obtain an unnecessarily long spiral.

(3) Penalizing the alinement by using too short spirals in order to decrease degree of curve when the net result is to decrease the maximum speed consistent with safety or comfort.

The recommended practice involves a principle that has already been applied in different ways by a number of roads, but which has not, to the best of the writer's knowledge, appeared in any textbook or discussion on the use of spirals prior to last January. The principle being that each rate of increase of spiral, as well as each degree of curve, sets a more or less definite limit on speed, and that in order to obtain the best results with the greatest economy a given spiral should be used with a given curve if such curve is relatively sharp enough to restrict the speed.

On January 12, 1909, after the report of the Committee on Track was in the hands of the printer, a paper was read before the Institute of Civil Engineers in London by Mr. W. H. Short, Associate Member Institute Civil Engineers, the following being an extract therefrom:

"The paper points out that the high speeds at which trains now run render it very important not only that the track should be of sufficient strength to carry the great weights put upon it, but also that its alinement should be perfect; so that trains entering and leaving curves may at all times travel not only safely, but so smoothly that passengers will not feel any discomfort whatever, whether the curves be sharp or flat. In order to secure this condition, it is necessary that all curves should be entered and left by transition curves.

"With regard to lines yet to be made there should be little difficulty in providing the necessary transition curves, as there will be no fixed obstacles in existence to interfere with the setting out by any of the methods already published; but the lines yet to be made in Great Britain are few in comparison with those already in existence, most of which have been constructed without transition curves. Hence the necessity for some simple and effective method of introducing, without serious expense, transition curves which will promote the smooth and safe running of trains at high speeds.

"Such a method has been devised by the author; it is believed to be original, and has been used with success on the London & South-Western Railway. The method is a graphical one, in which distorted scales are so used as to render very small differences of curvature clearly visible.

"Before describing the method the two following questions are discussed:

"(1) What is the true purpose of a transition curve?

"When a pure circular curve is entered directly from the straight, centrifugal force acts very suddenly on each vehicle; this sudden action of the centrifugal force produces a swing, similar to the swing of a pendulum-bob when drawn aside and released.

"As a rule, the outer rail on the straight leading to the curve is gradually superelevated, so that the proper amount of cant is attained at the entrance to the curve; but this cannot lessen the extent of the swing, although it lessens the sense of discomfort to the passengers.

"The over-swing or pendulum effect is augmented by reversal of curvature, and, consequently, it is at such points discomfort is most felt.

"The true purpose of a transition curve is, therefore, to enable the centrifugal force to be applied gradually, and so obviate the swing produced by its sudden action.

"(2) What is the most suitable length and form of transition curve?

"An efficient transition curve should allow of a rate of gain or loss of radial acceleration for the fastest trains just equal to the maximum amount that will pass unnoticed.

"The radial acceleration of a car moving v feet per second in a curve of r feet radius equals $\frac{v^2}{r}$; so that, neglecting the easing effect due to the length of a coach, the rate of gain of acceleration when a car enters a curve of r feet radius with a transition l feet long, at v feet per second, equals $\frac{v^3}{lr}$. In the author's experience, the maximum rate of gain or loss of acceleration that will pass unnoticed is 1 ft. per second per second in a second, so that l, the length of transition necessary, equals $\frac{v^3}{r}$ ft.

"It appears that eleven times the square root of the radius in chains represents the maximum speeds in miles per hour that are regularly attained over curves in practice, and, therefore, eliminating v from the above expression, it is shown that for practical purposes the suitable length of transition curve equals $\sqrt{R}$ chains.

"$V = 11\sqrt{R}$ being only true up to about 82 miles per hour, $L = \sqrt{R}$ only applies to curves of less than about 54.3 chains radius.

"Where speeds as high as $11\sqrt{R}$ are not probable, or even possible, the length of transition may be reduced, and is given by the expression $\frac{0.000724\ V^3}{R}$, where V is the maximum speed.

"The reciprocal of the rate of change of acceleration gives a measure of the efficiency of the transition curve; hence the efficiency of any transition curve of length L chains between a tangent and a curve of R chains radius under a speed of V miles per hour equals $\frac{1381 R L}{V^3}$.

"In all cases where the length of transition adopted is less than $\sqrt{R}$ this expression is extremely useful, as it enables a comparison to be made between a number of equally possible, but different, methods of improvement."

The interest displayed in the question of the proper length of spiral, as shown by the replies to the circulars sent out last year by the Committee on Track and as shown by the letter of Mr. Dennis, is gratifying, and it is to be hoped that further discussion will eventually lead to the revision and perfection of the recommended practice as adopted by the last convention.

Mr. John G. Sullivan (Canadian Pacific—by letter):—Referring to progress report of Track Committee, published on pp. 475-477, Bulletin 108, regarding spiral formulas, while the writer concurs with the conclusions and also with their remarks as to the objections to published formulas, he feels sure that it would be a benefit to the railway world if the objections mentioned by the Committee in their report were simply left out of published formulas.

The writer remembers well the first curve problem he had to solve after leaving college; although supposed to know all about these things, he did not really know whether the length of curve was to be measured on the arc or on the chord and was compelled to look up his fieldbooks.

Now, leaving out the minor fine points, which in actual practice are of really no importance, there are certain general principles of the spiral curve that if they were fully understood by the average fieldman spiral problems would become much more simple and the matter would be better understood by all parties.

For all practical purposes the spiral curve is a curve, if we may so state it, one step higher than the simple curve. To name some common properties and their differences, the writer would state them as follows:

The offset from the tangent to a simple curve for short distances varies as the square of the distance from the beginning of curve, while the offset from the beginning of a spiral varies as the cube of the distance.

While the middle ordinate of a given chord for a simple curve is uniform, the middle ordinate of a given chord for a spiral varies as the distance from the beginning of the spiral.

The deflections from the beginning of a simple curve to various points on the same vary directly as the distance; the deflections from

the beginning of a spiral to various points on the same vary as the square of the distance.

The deflection angle from the beginning of a simple curve to any point on the same is one-half the total central angle up to that point; the deflection angle from the beginning of a spiral to any point on the same is one-third the total central angle up to that point.

The degree of curvature on simple curves is constant; the degree of curvature on spirals varies as the distance from the beginning of spiral, and at any point is equal to the total angle up to that point, divided by half the distance from the beginning of spiral to that point.

The above, of course, is simply putting in words part of the formulas which the Committee have introduced in their report. Formula 1, page 476, i. e., $\Delta = \frac{LD}{200}$. Putting this into words, the writer would say that the spiral is twice the length of the simple curve it replaces, and that the angle of the spiral equals the angle of the simple curve which it replaces.

If the above principles were thoroughly understood and the field engineer was advised as to the length of the spirals to be used, the next problem that would confront him would be how to run these spirals on the ground.

The writer submits herewith two books of spiral tables prepared for the Canadian Pacific Railway Company. In our general work we use entirely the Holbrook method; the last table, however, on pp. 46 and 47, is an original table of coefficients and one to be used in special cases where an odd-minute degree of curve is to be spiraled or where a spiral of a certain length is desired for which the general tables do not give deflections.

To explain this table further than is explained in the instructions, the following example is given: Suppose it is desired to spiral a 6° 13′ curve with a spiral 400 ft. long. That will mean that the degree of curve at the end of spiral 400 ft. long will be 6° 13′; as the rate of change is constant, dividing 6° 13′ by 400 ft. will give .9325 min. as the rate of change per foot. Now by use of this table we can choose any number of chords (up to 25) into which this 400-ft. spiral can be divided, then with the transit set at any one of these points on the spiral, deflections to other points can be secured by multiplying the deflection from the beginning of spiral to the end of the first chord by the figures given on the horizontal line corresponding to the number of point at which transit is set.

Now as it is general practice to choose chords of an even number of feet, instead of figuring the deflection in the method given in our instructions, the writer would recommend the following practice, i. e., figure the degree of curvature at the end of the first chord, and from the relation between the degree of curvature and the deflection

obtain the first deflection. From formula 1, i. e., $\Delta = \frac{LD}{200}$ it is easily deduced that at the end of 25 ft. of any spiral Δ equals $\frac{1}{8}$ degree of curve:

At the end of 30 ft. Δ equals $\frac{3}{20}$ degree of curve
At the end of 40 ft. Δ equals $\frac{1}{5}$ degree of curve
At the end of 50 ft. Δ equals $\frac{1}{4}$ degree of curve
At the end of 60 ft. Δ equals $\frac{3}{10}$ degree of curve

and the first deflection being 1-3 of Δ we have the deflections for the first chord of the following lengths:

Deflection of first chord at end of 25 ft. = $\frac{1}{24}$ degree of curve.
Deflection of first chord at end of 30 ft. = $\frac{1}{20}$ degree of curve.
Deflection of first chord at end of 40 ft = $\frac{1}{15}$ degree of curve.
Deflection of first chord at end of 50 ft = $\frac{1}{12}$ degree of curve.
Deflection of first chord at end of 60 ft. = $\frac{1}{10}$ degree of curve.

Now returning to the problem of spiraling a 6° 13′ curve and choosing a 50-ft. chord the degree of curve at the end of 50 ft. will be 50 × .9325′, or 46.625′; the deflection for this first chord will be 1-12 of this, or 3.8854+′; for the second point, four times this amount, 15.5+′; for the third point nine times this amount, or 35—′, and the fourth point will be sixteen times this amount, or 1° 2+′, and so on, until the eighth point will be sixty-four times this amount, or 4° 8⅔′, which last deflection it will be noted is one-third of Δ. Running the curve from the other end the first deflection 3.8854+′ would be multiplied by 23, 44, 63, 80, 95, 108, 119 and 128, and it will be noticed that the last deflection will give 8° 17⅓′, which is ⅔ of Δ.

If a 25-ft. sub-chord was chosen the degree of curve at the end of the first chord would have been 25 × .9325′, or 23.3125′, and the deflection for the end of the first chord would be 1-24 of this, or .9713′, and this deflection multiplied by the figures given in the first column up to 16, end of curve, will give the deflections for the sixteen different points. Running curve the other way, beginning with 47 and ending with 512, will give the deflections running the spiral from the end of the curve to the tangent.

Now if it was necessary to set up the transit on any intermediate point, for example, point No. 9. the deflections both ways from this point would be obtained by multiplying the first deflection .9713 by the figures on the horizontal line marked "9," from 25 to 162, running toward point of spiral, and by 28 to 238 in running toward beginning of curve.

It will be understood, of course, that in this example an extreme case has been taken, and that generally, instead of dealing with long fractions, we would have only even minutes to deal with.

Mr. J. B. Jenkins (Baltimore & Ohio—by letter):—The Track Committee, in its progress report, named the following objections, one or more of which apply to all existing formulas:

(1) They are too complicated for convenience in field work and in calculations.

(2) They are in the form of infinite series, giving slightly varying results dependent on the number of terms used.

(3) They are roughly approximate and not mathematically related one with another.

Mr. Sullivan, while concurring in these objections, suggests that these objections simply be left out of published formulas and suggests a statement of principles in lieu of formulas.

The principles suggested are well known as approximate expressions of the properties of the railroad spiral, but are as unsuited for the calculation of tables or for other mathematical operations as the assumption that "the offset from the tangent to a simple curve for short distances varies as the square of the distance from the beginning of the curve" is unsuited for calculating the circular curve.

The true cubic parabola, the curve which exactly fulfills the conditions of the first principle named by Mr. Sullivan, is open to all three objections, for while it gives the simple formulas

$$Y = kX^3 \qquad \tan\Delta = \frac{3Y}{X}, \qquad \tan A = \frac{Y}{X}, \qquad \tan A = \tfrac{1}{3}\tan\Delta$$

$$C = X\sec A, \qquad U = \tfrac{2}{3}X \quad \text{and} \quad V = \tfrac{1}{3}X\sec\Delta,$$

these equations are grossly inconsistent with the fundamental formula of the spiral $\Delta = \frac{DL}{200}$ when large angles are involved, and it is fully as difficult to express any of the above quantities in terms of *L* as it is in the case of the true railroad spiral.

A single example of its inadaptability is that when $\Delta = 40°$, then $A = 15°37'35''$, while for the true railroad spiral $(\Delta = \frac{DL}{200})$, $A = 13°16'48''$.

A modification of the cubic parabola, which consists in making the offsets from the tangent vary as the cube of the length measured along the spiral for the first half and making the offsets from the circular curve vary as the cube of the length measured along the spiral for the second half, fulfills every requirement for easy riding and is very easily staked by offsets, but the calculation of the abscissa of the beginning of the circular curve (Z) is very awkward, and, each half of the spiral being in reality an independent curve, a 250-ft. spiral to a 5-degree curve would be somewhat different from the first half of a 500-ft. spiral to a 10-degree curve; the deflection angles, too, have a most peculiar relation to length and central angle when the latter is large.

The degree of curve in such a spiral, while not increasing exactly in proportion to the length, does so approximately, and there is abso-

lute continuity, if not absolute uniformity, in the curve; furthermore, it is tangent to the circular curve. The only objection to such a curve is the difficulty of giving formulas for its calculation and of reproducing it by means of deflections. The principle can be applied, however, in laying out a spiral whose offset and tangent distance has been computed from another assumption, the only difference between a spiral thus laid out and one run by deflections being an almost inappreciable outward swing in the first half and a similar inward swing in the second half of the spiral, the curvature increasing a little slower at the ends and a little faster in the middle than a uniform rate.

The second principle suggested by Mr. Sullivan is, of course, as nearly true as that the middle ordinate of a circular curve is arithmetically proportional to the degree of curve; this principle is of great value to the trackman in lining up a spiral.

The third and fourth principles hold almost absolutely up to a central angle of 10 degrees; they should not be applied when the central angle greatly exceeds 15 degrees; if applied to a central angle of 40 degrees, the spiral will not be tangent to the circular curve, but will intersect it at an angle of about 0°10′.

The fifth principle stated by Mr. Sullivan, "The degree of curvature on spirals varies as the distance from the beginning of spiral and at any point is equal to the total angle up to that point, divided by half the distance (in stations) from the beginning of the spiral to that point," is the fundamental principle upon which the true railroad spiral is based, and upon which nearly all spiral formulas and tables are founded. The discrepancy between different tables lies not so much in the way this last principle is applied as in the too free application of the other so-called "principles," which do not, or should not, govern the form of the spiral, but which are merely "properties" of the spiral which are true only within certain limits.

The following table shows comparatively the deflection angle, long chord, co-ordinates of the end of spiral and co-ordinates of the beginning of the offsetted circular curve as given in several tables for each alternate chord-point of a spiral whose curvature increases 1 degree per 50-ft. chord. It may be stated that Talbot does not specify the length of chord to be used, and that Holbrook's, Talbot's and Crandall's tables are computed for arc measurement; also that the values of o and Z are computed by Holbrook from the formula $R = \dfrac{5729.58}{D}$, and by Talbot and Crandall from $R = \dfrac{5730}{D}$. The table also gives the actual quantities computed from the angles between each separate chord and tangent, o and Z being derived from $R = 50 \operatorname{cosec} \frac{1}{2} D$; and, finally though not pertinent to this discussion, are added the quantities derived

from the formulas given in the Track Committee's progress report, these formulas being based on the assumption that each point is reached, not by 50-ft. chords, but by ten equal chords.

The spiral which increases 1 degree per 50 ft. is chosen for comparison because it has probably been more frequently used than any other.

COMPARISON OF TRUE PROPERTIES OF A SPIRAL, RATE OF INCREASE 1° PER 50-FOOT CHORD, WITH PROPERTIES AS GIVEN BY SEVERAL AUTHORS. (TRACK COMMITTEE'S NOTATION.)

Author	L	D	Δ	A	C	X	Y	Z	O
True Value....	100	2°	1°	0°20'00"	99.999	99.997	0.582	49.997	0.145
Holbrook......	100	2°	1°	0°20'12"	....	99.994	0.582	50.000	0.146
Sullivan.......	100	2°	1°	0°20'	100.00	100.00	0.58	50.00	0.15
Crandall.......	100	2°	1°	0°20'	100.0	100 00	0.58	50.0	0.14
Talbot.........	100	2°	1°	0°20'	100.00	100.00	0.58	50.00	0.15
Track Com....	100	2°	1°	0°20'00"	99.999	99.997	0.582	49.997	0.145
True Value....	200	4°	4°	1°20'00"	199.960	199.906	4.653	99.967	1.163
Holbrook......	200	4°	4°	1°20'04"	....	199.805	4.655	99.886	1.166
Sullivan.......	200	4°	4°	1°20'00"	199.97	199.91	4.65	99.97	1.16
Crandall..	200	4°	4°	1°20'00"	200.0	199.90	4.65	100.0	1.16
Talbot.........	200	4°	4°	1°20'00"	199.96	199 90	4.65	99.97	1.16
Track Com....	200	4°	4°	1°20'00"	199.957	199.903	4.653	99.964	1.163
True Value....	300	6°	9°	2°59'58"	299.682	299.272	15.681	149.820	3.919
Holbrook......	300	6°	9°	3°00'45"	....	298.519	15.712	149.135	3.955
Sullivan.......	300	6°	9°	3°00'	299.73	299.32	15.69	149.87	3.93
Crandall.......	300	6°	9°	3°00'	299.7	299.26	15.68	149.9	3.92
Talbot.........	300	6°	9°	3°00'	299.67	299.26	15.68	149.88	3.91
Track Com....	300	6°	9°	2°59'58"	299.675	299.265	15.681	149.813	3.919
True Value...	400	8°	16°	5°19'48"	398.642	396.919	37.031	199.348	9.264
Holbrook......	400	8°	16°	5°24'11"	....	393.759	37.243	196.350	9.499
Sullivan.......	400	8°	16°	5°20'	398.69	396.97	37.04	197.57	9.26
Crandall.......	400	8°	16°	5°19.8'	398.6	396.89	37.02	199.5	9.27
Talbot.........	400	8°	16°	5°20'	398.62	396.89	37.04	199.48	9.28
Track Com....	400	8°	16°	5°19'48"	398.633	396.909	37.030	199.338	9.263
True Value....	500	10°	25°	8°19'14"	495.834	490.615	71.753	248.165	18.003
Sullivan.......	500	10°	25°	8°20'	497.01	491.76	71.48	242.45	17.92
Crandall.......	500	10°	25°	8°19.2'	495.8	490.57	71.73	248.4	18.05
Talbot.........	500	10°	25°	8°19'	495.82	490.59	71.72	248.40	18.05
Track Com....	500	10°	25°	8°19'13"	495.835	490.616	71.750	248.166	18.000
True Value....	600	12°	36°	11°57'39.5"	589.627	576.826	122.197	295.666	30.843
Crandall.......	600	12°	36°	11°57.5'	589.6	576.74	122.16	296.1	30.96
Talbot.........	600	12°	36°	11°58'	589.70	576.82	122.13	296.08	30.97
Track Com....	600	12°	36°	11°57'40"	589.666	576.863	122.207	295.703	30.853

The above comparison shows errors of 3 ft. in Holbrook's tables, several of more than a foot and one of 5.7 ft. in Sullivan's tables, which goes to show that the properties of the spiral, which Mr. Sullivan would state as principles in lieu of formulas, are open to the third objection named by the Track Committee: "They are roughly approximate and not mathematically related one with another."

The minor differences between values obtained from Talbot's and Crandall's carefully worked-out tables show the difficulty of obtaining absolute results with infinite-series equations; and while the differences are unimportant in railroad work, they are greater than would be tolerated in the solution of ordinary trigonometrical problems; and

there are very few transitmen or computers who are able to make a new and tolerably accurate spiral table from any of the present accepted formulas without a vast amount of worry and trouble.

The writer does not believe that any formulas can be derived which will be free from all objections named by the Committee; but the formulas proposed by the Committee are free from the endless-series objection, are correct to the utmost limit of instrumental accuracy if the work is done in accordance with the hypothesis that the spiral is made up of ten chords, are usually more accurate than formulas based on arc-measurement if the work is done without regard to chord-length, the quantities have exact trigonometrical relations one to another and the formulas are less complicated and easier of solution than most of the accepted formulas.

The Track Committee's formulas are still open to the objection that they are too complicated for field use, but the Committee hopes to submit a supplemental series of empirical formulas for that purpose which will be both accurate and convenient.

REPORT OF COMMITTEE NO. III—ON TIES.

(Bulletin 108.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee on Ties has held three meetings during the year, in addition to meetings of the sub-committees. Meetings of the General Committee were held as follows: Washington, D. C., May 22; Atlantic City, August 31; Chicago, November 23, 1908.

The following members attended meetings of the Committee: E. B. Cushing, Chairman; E. G. Ericson, Vice-Chairman; J. B. Austin, Jr., W. F. H. Finke, E. E. Hart, E. D. Jackson, A. W. Thompson, Dr. Hermann Von Schrenk.

Sub-Committees were appointed as follows:

A—Compilation of Statistics: J. B. Austin, Jr., Chairman; A. W. Thompson, F. B. Oren.

B—Timber Supply: Dr. Hermann Von Schrenk, Chairman; W. F. H. Finke, E. D. Jackson.

C—Metal Ties: E. E. Hart, Chairman; E. G. Ericson, W. F. H. Finke.

The following subjects were assigned to your Committee by the Board of Direction:

(1) *Continue the compilation of statistics upon the life of ties, both treated and untreated, and the causes of failure. Present summary compilation of reports received and draw such conclusions therefrom as the statistics warrant at the present time.*

In Appendix A the Committee submits a revision of the blank forms heretofore adopted by the Association for the collection of tie statistics. The Committee recommends that the forms now appearing in the Manual of Recommended Practice be withdrawn and the new forms substituted.

(2) *Prepare critical review of the general question of the present and future status of the tie supply, the various methods heretofore adopted for reducing the yearly demands on the timber supply, and what general lines of investigation and change in existing methods may seem most desirable to be followed so as to secure the best results in the future.*

In Appendix B your Committee presents a discussion of the present status of the tie supply question, with recommendations.

(3) *Collect statistics on the extent of the use and the life of metal or composite ties up to the present time, with illustrations and descriptions of the most successful designs, and draw such conclusions as the conditions may warrant.*

The Sub-Committee having the foregoing subject in charge has inspected the various devices described in Appendix C, and the illustrations accompanying the report have been taken by it on the ground.

CONCLUSIONS.

Your Committee recommends the adoption of the following conclusions:

(1) That Forms 1, 1-A, 1-B, 1-C and 1-D be withdrawn from the Manual and Forms M. W. 301, M. W. 302, M. W. 303, M. W. 304 and M. W. 305 be substituted.

(2) That the conclusions in reference to Timber Supply be approved.

*(3) That the conclusions of the Committee in reference to Metal and Concrete Ties be endorsed.

Respectfully submitted,

E. B. Cushing, Southern Pacific Company, Houston, Texas, *Chairman.*

E. G. Ericson, Principal Assistant Engineer, Northwest System, Pennsylvania Lines, Pittsburg, Pa., *Vice-Chairman.*

J. B. Austin, Jr., Engineer Maintenance of Way, Long Island Railroad, Jamaica, N. Y.

W. F. H. Finke, Tie and Timber Agent, Southern Railway, Washington, D. C.

E. E. Hart, Chief Engineer, New York, Chicago & St. Louis Railway, Cleveland, O.

E. D. Jackson, Assistant Engineer Maintenance of Way, Baltimore & Ohio Railroad, Baltimore, Md.

F. B. Oren, Roadmaster, Illinois Central Railroad, Nashville, Tenn.

H. J. Simmons, General Manager, El Paso & Southwestern Railway System, El Paso, Tex.

A. W. Thompson, Chief Engineer Maintenance of Way, Baltimore & Ohio Railroad, Baltimore, Md.

Dr. Hermann Von Schrenk, Supervisor of Timber Preservation, Rock Island, Chicago & Eastern Illinois, and Frisco Railways, St. Louis, Mo.

Committee.

*Amend to read: "That the conclusions of the Committee in reference to Metal and Concrete Ties be received as information."

Appendix A.

COMPILATION OF STATISTICS.

Your Committee was instructed by the Board of Direction to continue the compilation of statistics on the life of ties, both treated and untreated, and the causes of failures.

The Association adopted at the Third Annual Convention in 1902 certain forms to be used in the compilation of statistics. The forms were sent out to various railroads, but no general reply was received to them, nor has sufficient information been thus collected to justify the Committee in drawing any conclusions as requested for this year's report.

It is now deemed advisable to make some changes in the blanks as adopted by the Association in order that the destruction between so-called long and short lived, treated and untreated ties may be clearly brought out, together with further information it is thought desirable to collect.

The changes in the new blanks and reasons therefor are as follows:

Form 1 (*M. W.* 301).

Column 4.—It is thought that the word "average" is misleading. This report it is hoped will be made out annually, and therefore the actual ton miles per year can be given.

Columns 25, 26 and 27.—It is considered advisable to show opposite each class of wood its average life in each track, rather than the very general information only, possible with the old form.

Column 28.—This information is given in columns 26. 29, 32 and in form 302. In place of column 28 it is thought that information relative to climatic conditions would be of value, as these conditions have a material bearing on the life of ties.

Form 1-*A* (*M. W.* 302).

Unchanged except process left blank.

Form 1-*B* (*M. W.* 303).

Remarks in regard to classification of ties same as in preceding cases. By omitting printing the years, the reprinting of blanks each year will be dispensed with.

Form 1-*C* (*M. W.* 304).

This blank has been modified slightly to provide for all treating processes.

Form 1-*D* (*M. W.* 305).

Changed only so as to provide for treated and untreated ties.

The Committee therefore recommends the adoption of blanks as amended and that they be distributed among the railroads annually, for the compilation of tie statistics that will be of great value to all users of ties.

Form M. W. 305

A., B. & C. R. R. CO.

FOREMAN'S TIE REMOVAL REPORT.

Section No.............. Division........... Month of.............19...

Removed from Main Tracks.					Removed from Side Tracks.			
Number Removed	Year Put in.	Kind of		Cause.	Number Removed	Year Put in.	Kind of	
		Timber.	Treatment.*				Timber.	Treatm'nt.*

This blank must be sent in monthly by all Foremen, whether any ties have been removed or not. When no ties have been removed, it must be so stated on the blank.

After approval by.................. it is to be forwarded to..............

....
Foreman.

*Note. When untreated ties are removed, make a dash (—) in "Treatment" column.

CROSS-TIES RECORDS.

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Appendix B.

TIMBER SUPPLY.

The Sub-Committee on Forest Supplies has during the past year devoted its attention principally to investigating policies which could be followed at this time to encourage the more economical uses of the timber supplies still on hand. This problem is such a large one that it has not been thought desirable to make more than a progress report.

It has been found that the most important need for most of the railroads at this time is definite technical information. It is not sufficient to know that timber supplies are being exhausted, but one should also know exactly what these supplies are, and what the rate of exhaustion is, and what the probable rate of re-growth is in any particular region upon which that particular road is depending. Your Committee feels very strongly that one of the most important steps which the various individual roads could take would consist in the appointment of technical men in connection with their timber departments to study this problem with the greatest care. The need of such investigation is being universally felt, and has manifested itself during the last year in very striking form, as shown by the two meetings of the Governors of the various States, called by the President in May and December, in Washington, D. C. While the general results of these conferences were largely of an educational nature, it was nevertheless very evident from the expressions of the various speakers at these conferences, that the problem of a probable adequate timber supply would be determined entirely by definite, practical co-operation between the individuals owning the timberlands and the State and National Governments. At these sessions it was pointed out that it would be necessary for the State and National Governments to adopt such measures and enact such laws as would tend to encourage the owners of timberlands to develop them, with a view toward future forest reproduction. It was pointed out that the question of taxation of these timberlands was the most important one in this connection. Under the system of taxation existing in most of the States it is practically impossible for the owners of timberlands to do anything else than to cut the timber, irrespective of its future possibilities. It was with this realization that the National Conservation Committee made the following statement:

"We tax our forests under the general property tax, a method of taxation abandoned long ago by every great nation. Present tax

laws invite destructive logging and prevent the restoration of cut-over lands. The true remedy for excessive forest taxation lies not in special exception nor in laxity in the application of existing laws, but in a change in the method of taxation. An annual tax on the land itself, exclusive of the timber, and a tax on the timber when cut, is well suited to the conditions of forest investment, and is practicable and certain. It is better that the forest should pay a moderate tax permanently than that it should pay an excessive tax temporarily and then cease to yield at all."

As working conclusions, your Committee can simply repeat some of the recommendations made in its report last year, and urge their immediate consideration:

*(1) Use chemically treated ties wherever possible.

†(2) Protect such treated ties against mechanical wear by means of tieplates, screw-spikes, etc.

‡(3) Enforce the tie specifications rigidly with particular reference to the rigid exclusion of small ties.

(4) Co-operation among the roads in any given territory, looking toward the adoption of standard tie specifications, with particular reference to making it impossible for contractors to furnish ties cut from small trees, which would naturally form sources for future tie supplies.

(5) Adopt measures for reducing forest fires.

(6) Encourage the owners to re-forest their lands either by re-planting or natural reproduction.

(7) Use the proper means to aid and assist in the investigation of tax laws as far as they pertain to forest lands with a view to having legislation enacted which would make it possible to hold lands with growing timber for the purpose of future tie production.

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*Change word "possible" to "practicable."
†Amend to read: "Protect all ties against failure from mechanical wear."
‡Omit word "rigid" in second line.

Appendix C.

METAL AND COMPOSITE TIES.

The subject of "collection of statistics in regard to the use and life of metal and composite ties, with descriptions, and illustrations of the most successful designs, and conclusions drawn therefrom," was assigned to a Sub-Committee composed of E. E. Hart, Chairman; E. G. Ericson and W. F. H. Finke. The Sub-Committee has inspected the various devices described below, and the illustrations have been taken by it on the ground.

"A"—STEEL TIES.

CARNEGIE STEEL TIES (BUHRER PATENT).

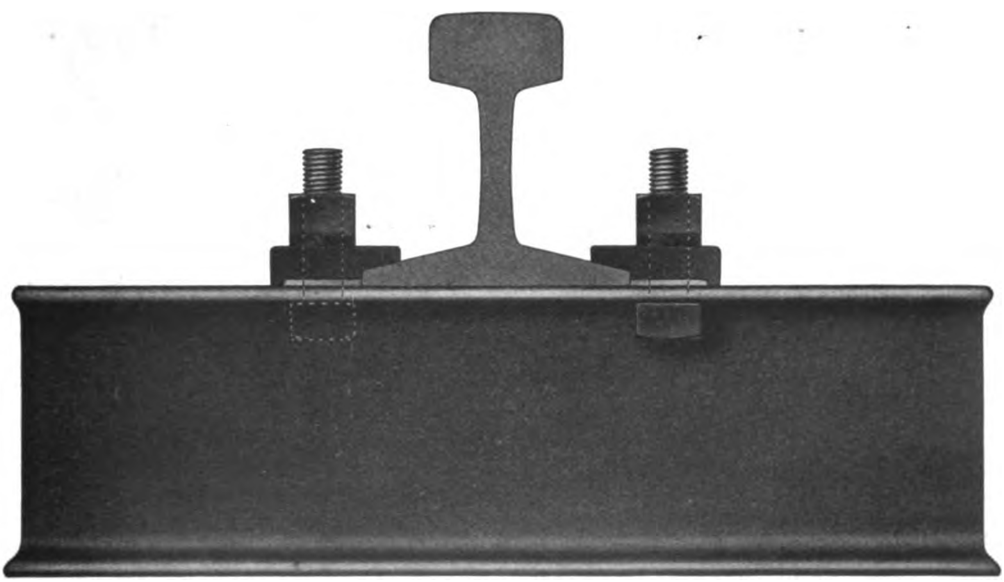


Fig. 1 shows in a general way this form of tie. There are approximately 1,200,000 steel ties of the Carnegie type, Buhrer Patent, in use throughout the country. As far as we have observed this tie it has fulfilled the requirements of a first-class tie, meeting the requirements fully as to gage, surface, level and alinement, where good ballast was in use.

Buffalo, Rochester & Pittsburg Railroad.

E. F. Robinson, Chief Engineer, advises that they have 3,000 of the Carnegie Steel Ties in use, 1,500 at Colden, N. Y., and 1,500 at Ridgway, Pa. The track at Colden is ballasted with stone and at Ridgway with hard slag. So far these ties have given good service. He further states that at first they had some trouble with the fastenings, when cinders were used for ballast, but since this ballast has been replaced with slag the fastenings have not given any trouble.

So far as could be determined by the Committee, the steel tie gives a more solid and quiet track than the wood tie, due to the rigid fastening of rail to the tie. Apparently there is less vertical movement of track on the steel tie than on the wood. The Roadmaster stated that the cost of surfacing and lining was practically the same as for wood ties.

Bessemer & Lake Erie Railroad.

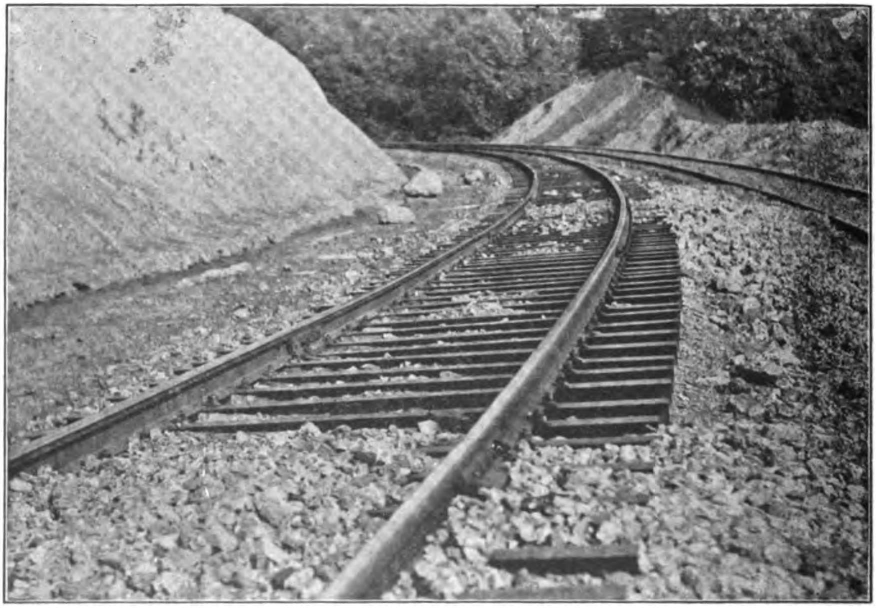


FIG. 2.

Fig. 2 shows the steel ties in use on a sharp curve east of Conneaut, Ohio, the ballast being only partly filled in. Gage, alinement and level were good, as will be noted from the above illustration. The track men express a preference for the steel tie, claiming that with the steel tie track is easier to maintain than with wood ties.

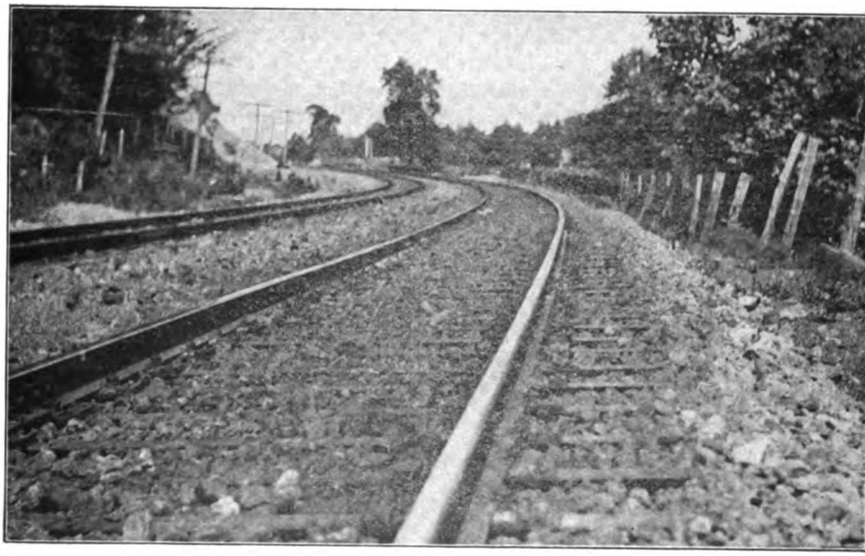


FIG. 3.

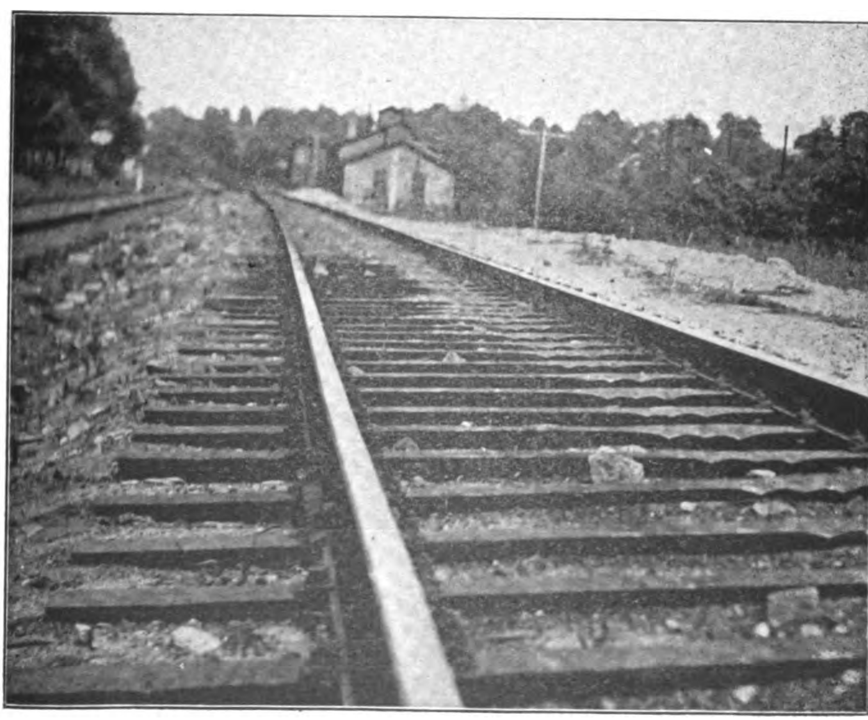


FIG. 4.

Fig. 3 shows the insulated tie now in use on the Bessemer & Lake Erie Railroad. The insulated tie is made by placing a piece of fiber on the steel tie and then firmly riveting a steel plate over the top of the fiber for the rail to rest on. This is intended to stop all wear on the fiber.

The insulated ties, just east of Conneaut, Ohio, have only recently been put into the track. As to length of time the fiber plate will last, that has not as yet been determined, but the tie gives the appearance of meeting the requirements as to insulation.

Fig. 4 shows the effect of three derailments, which in this case merely bent down the upper flange of the ties and in no way injured their usefulness as a tie. So far as the Committee was able to learn the steel ties give a stronger track than the wood tie and spike. Bolts and clamps holding rail were tight in most cases, and seemed to be holding the ties firmly to rail.

Fig. 5.

Fig. 5 shows the ties used in open track on construction work. The Committee also saw them in use on trestles where filling was being done. Mr. Layng, of the Bessemer road, claims that his men use very little more time in laying the steel ties than they do in laying wood.

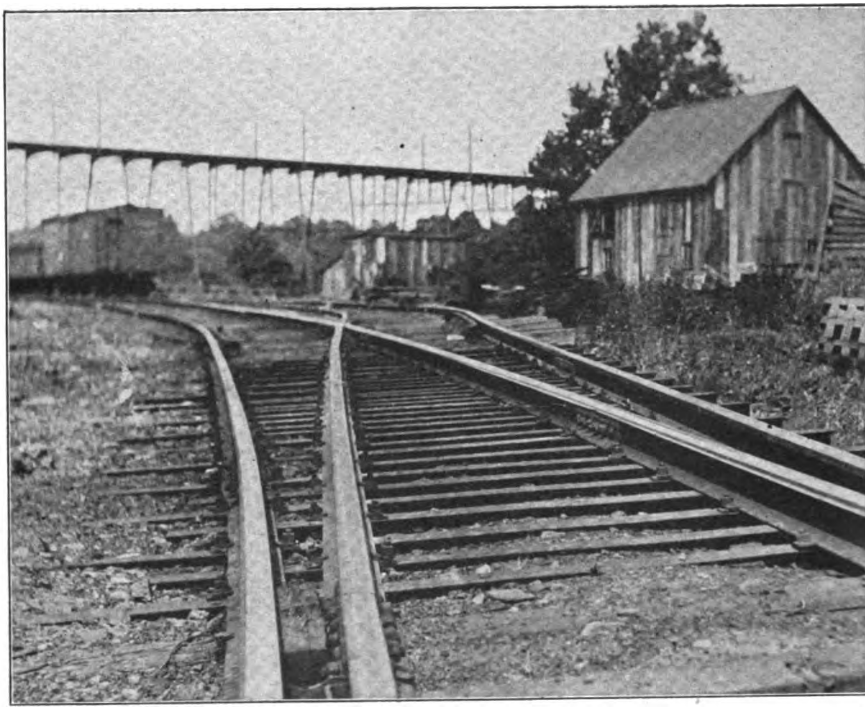


FIG. 6.

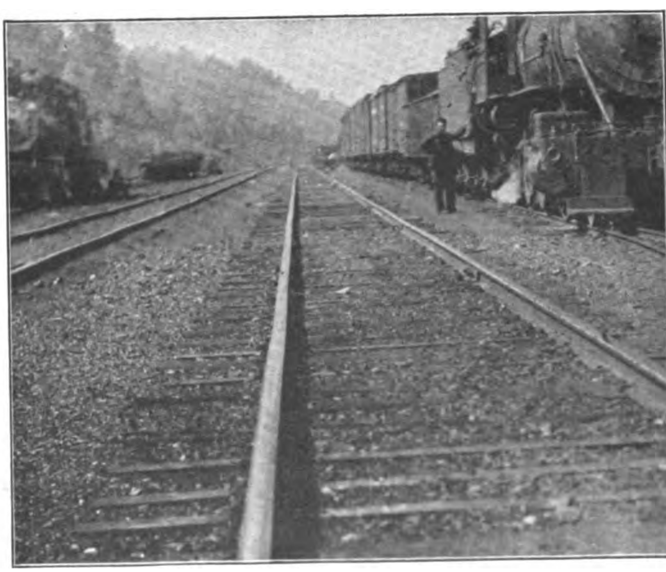


FIG. 7.

Fig. 6 shows steel ties used as switchties, the ties being lapped. Eight and one-half foot ties are used in this case.

Fig. 7 shows the steel and wood ties mixed. It seems to be the practice on the Bessemer road when a wood tie fails, to replace it with a steel tie. The Committee also saw on curves that steel ties had been sandwiched in for the purpose of holding the track to gage, where ballast was poor and tracks were sliding and spreading. The Bessemer road claims that by using steel ties this trouble can be stopped and good gage maintained until such a time as they can entirely replace the old wooden ties with the Carnegie Steel Ties.

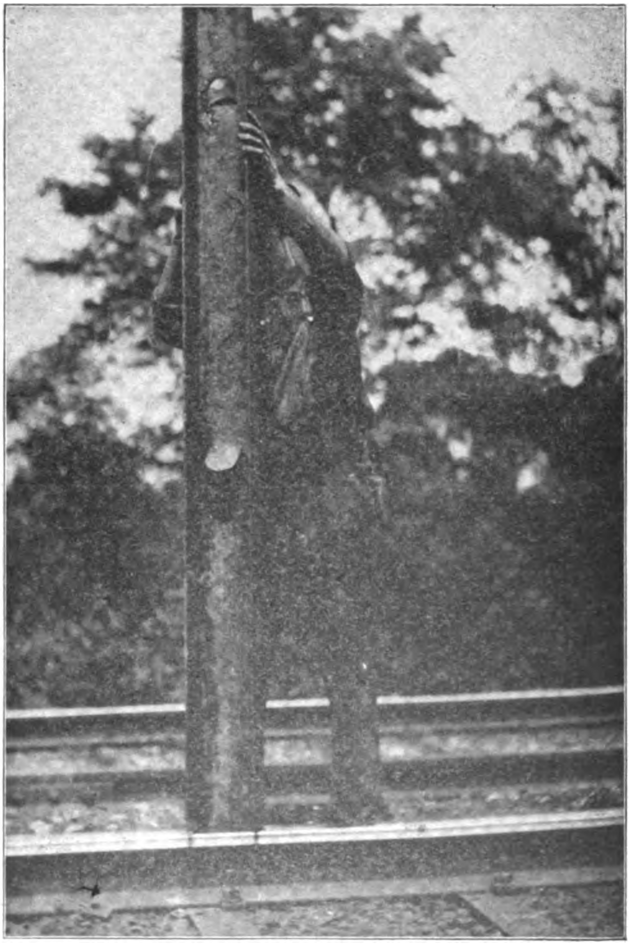


Fig. 8.

Fig. 8 shows a steel tie taken from the track that had been in service four years. Very little rust was found on the web of the tie. The bottom flange of this tie showed very little corrosion. There were no signs whatever of the tie failing in any respect. Mr. Layng also stated that the cutting of slots or holes in the web of the tie had been abandoned, as they found that with slag or stone ballast the holes with the web turned out were not necessary in order to keep the track from sliding sideways.

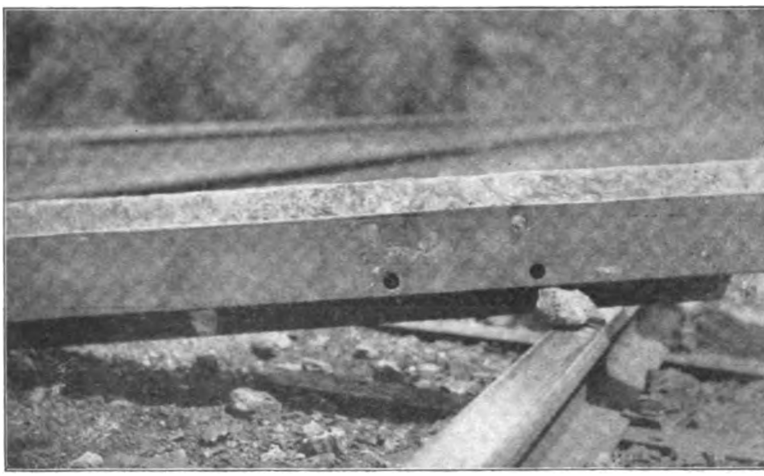


Fig. 9.

Fig. 9 is a photograph of the same tie showing the upper face where the base of rail rests. The tie seemed to be smooth under the rail and showed very little wear, if any. The wear could barely be felt when passing the hand over the tie. Bolts and clips showed very little wear.

Providing the wear in years to come is no greater in proportion than it has been during the past four years, the tie will be good for 25 or 30 years. The Committee observed the fastenings very closely, bolts, angle bars, clips, and in fact all parts of the steel tie track, and reached the conclusion that first-class track can be maintained with the present form of Carnegie Steel Tie and fastening. The track foremen advised us that after the bolts were tight and nuts set they had no further trouble with the gage or fastenings. They also stated that when new track was laid, the bolts holding the clips had to be tightened once or twice after track was laid before they took a tight set.

Fig. 10 is a general view of insulated steel ties in track, which is typical of all the steel tie track on the Bessemer road.

Fig. 11 is another general view of the steel ties on curve on the Bessemer road, showing good conditions as to line and gage.

FIG. 10.

FIG. 11.

New York Central & Hudson River Railroad.

About one mile of Carnegie Steel Ties were laid in the main track near Castleton, N. Y., in the year 1904. Early in 1907 this track was

turned into a siding or freight track, and it is evident since that time nothing has been done to the track in the way of keeping it in line and surface, or in keeping the bolts tight. No reliable data as to the use and life of these ties could be had. Very little loss of cross-section by rust was in evidence.

Pitsburg & Lake Erie Railroad.

Two types of steel ties of the Carnegie design are used on this road. One with the regular Carnegie clip fastening, and one on which the rail is fastened to the ties by means of a clip and web.

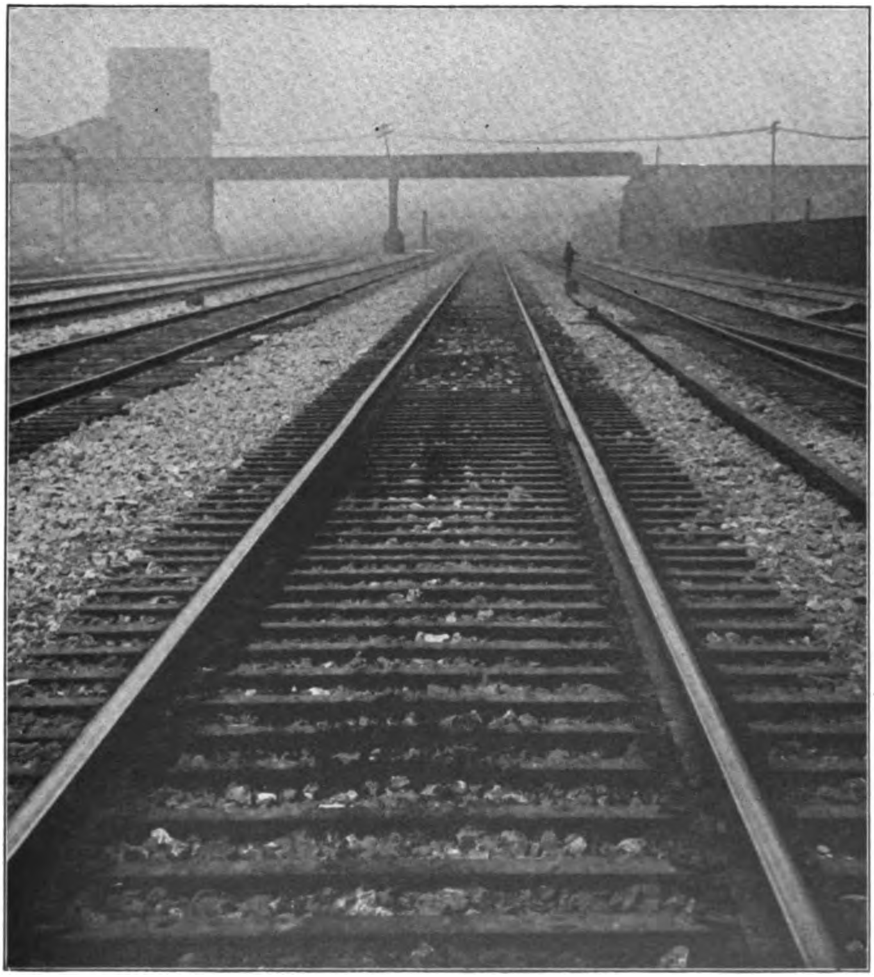


FIG. 12.

Fig. 12 shows the Carnegie Steel Ties in the Pittsburg & Lake Erie tracks at Pittsburg. Three thousand of these ties were placed in their No. 3 low-speed freight track at McKees Rocks during September, 1907. These ties are of the regular type with a clip and bolt fastening, and a fiber plate for insulation placed on top of the tie, with rail bearing directly on the fiber. The electric circuits have been maintained with no special trouble. The track is in good gage, line and surface. The Committee is advised that the track with steel ties is kept in surface and line with the same amount of labor as the track with wooden cross-ties.

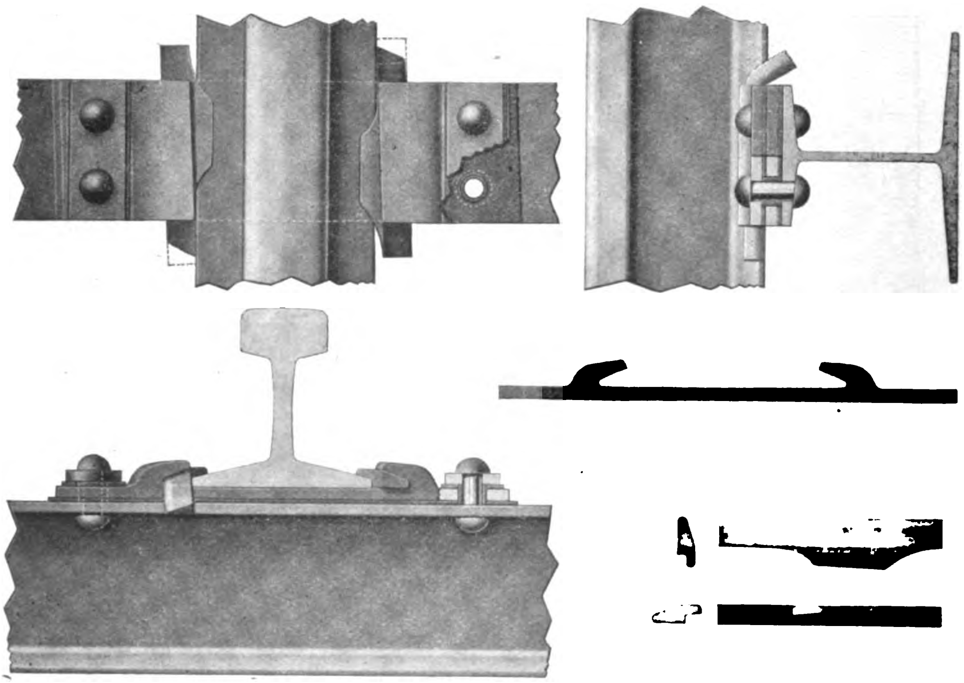


FIG. 13.

Figs. 13 and 14 show the Carnegie Steel Tie with the wedge fastener. These ties have been in the track only a short time and should be looked up and reported on next year.

Union Railroad (of Pittsburg).

Five thousand Carnegie Steel Ties with the wedge fastening above described were put into the track during the fall of 1908.

Baltimore & Ohio Railroad.

During November, 1906, one mile of steel ties were laid on the old main line east of Marriottsville, Md.

In June, 1908, one mile of oak ties were put in for comparison and at that time both stretches of ties were fully ballasted with stone. The alinement is about 62 per cent. curve, maximum curvature being 9° 30'. Grade .03 per cent. Traffic is in one direction only, down grade, and extremely heavy.

The result so far, as reported by the Baltimore & Ohio people, is in favor of the wooden tie.

Pennsylvania Lines West of Pittsburg.

Seitz Iron Tie.—(Fig. 15). Forty-nine of these ties were put in main track during October, 1904, at Emsworth, Pa., on the Pennsylvania Lines West of Pittsburg. In April, 1905, thirteen of these were removed on account of being broken under the rail, and the rest were removed in September, 1905, for the same reason.

Fig. 14.

Hansen Tie (Fig. 16) (Made by the Standard Steel Car Co.).—Five hundred of these ties were placed in the track July, 1905, near Emsworth, Pa., on Pennsylvania Lines West of Pittsburg. A great deal of trouble was experienced with the insulation, also from the ties sliding transversely and longitudinally through the stone ballast, and the ties were in consequence removed from the main track in November, 1905, and placed in a passing siding, where they are still in service.

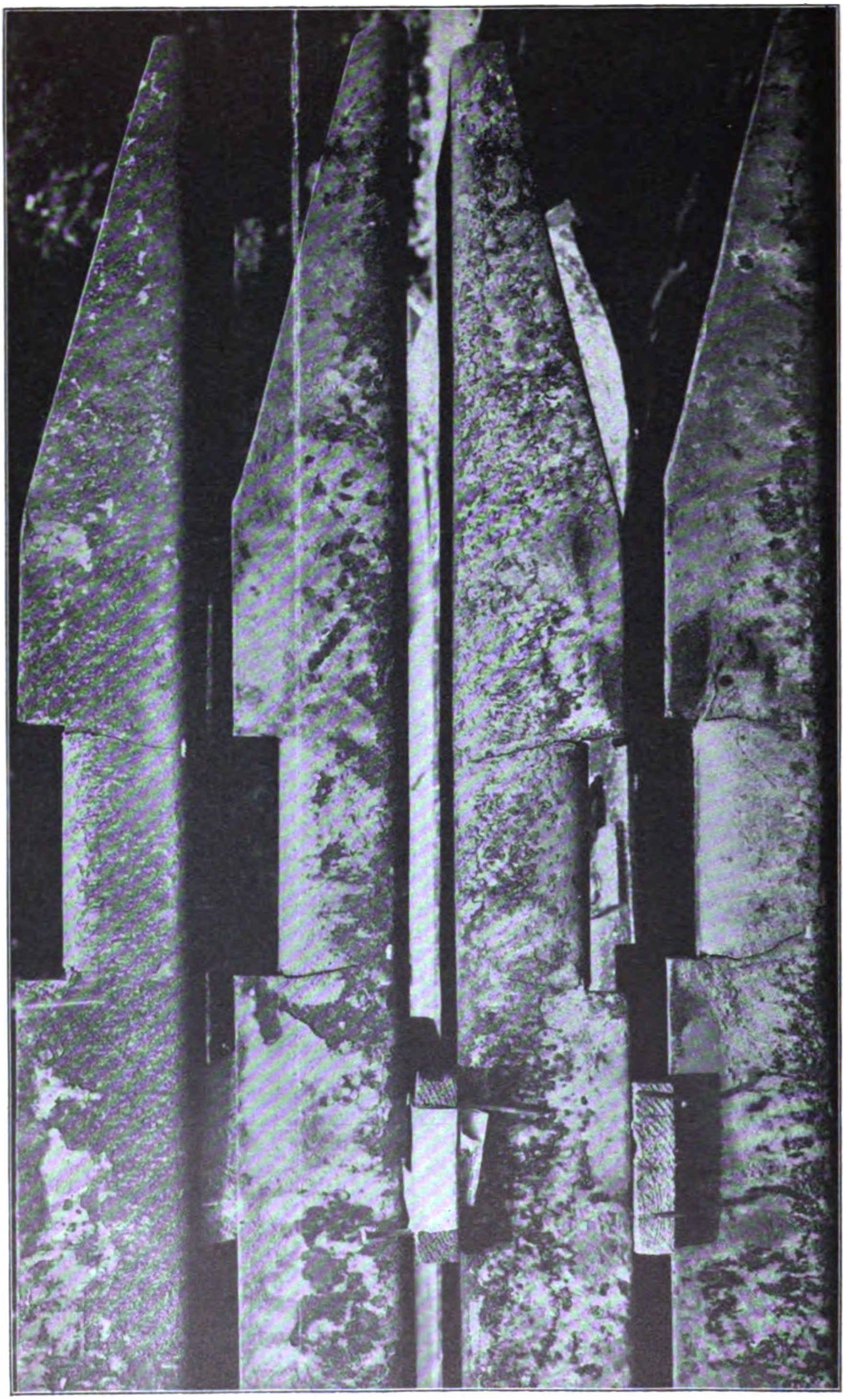


FIG. 15.

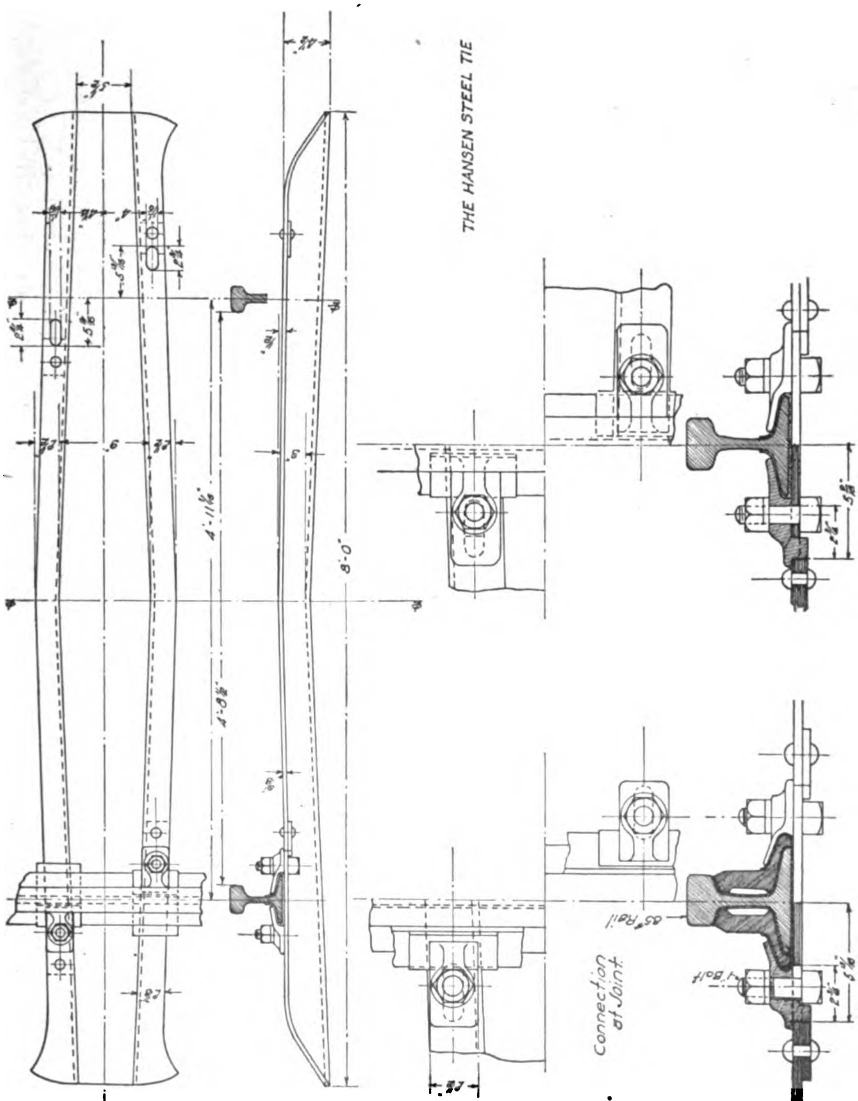


FIG. 16.

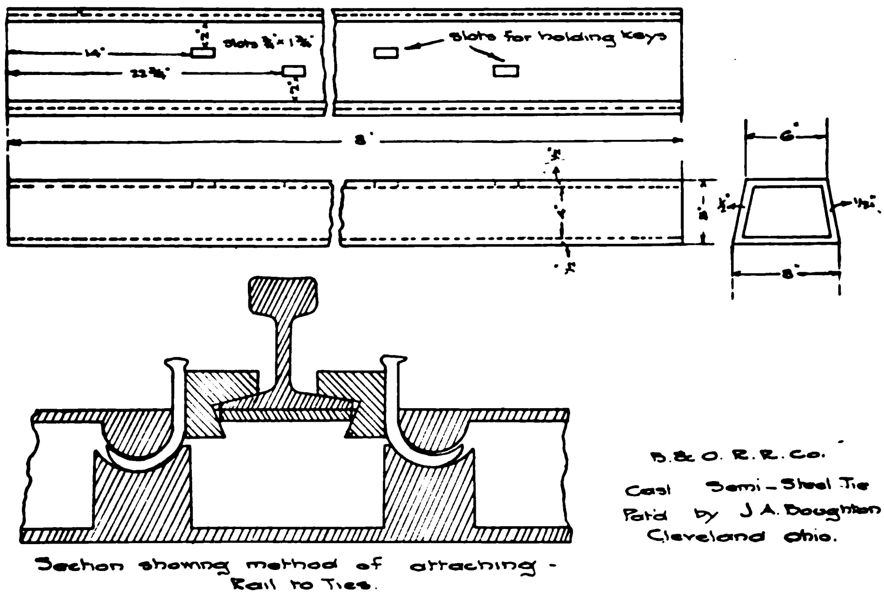


FIG. 17.

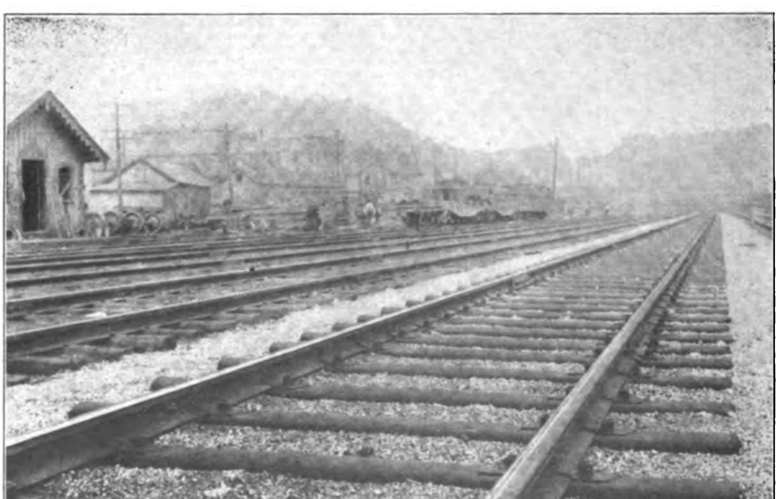


FIG. 17-a.

Bouton Steel Tie (Fig. 17).—Eighteen of these were placed in the track of the Baltimore & Ohio Railroad near Akron, Ohio. They are reported to have given good service.

Fig. 17-a shows the Snyder Steel Tie in the Conemaugh yards on the Pennsylvania Railroad. There is also about one mile of these ties in use at Derry, Pa., on the Pennsylvania Railroad, none of them being in the main tracks. The standard type of the Snyder tie consists of a steel shell $\frac{3}{16}$ in. thick, 8 ft. long, 7 in. wide, 7 in. deep, and with the bottom open. The interior of the shell is filled with a mixture of asphalt and crushed stone. This tie was patented three years ago by John Snyder.

The ties at Conemaugh and Derry, Pa., have now been in use about one year.

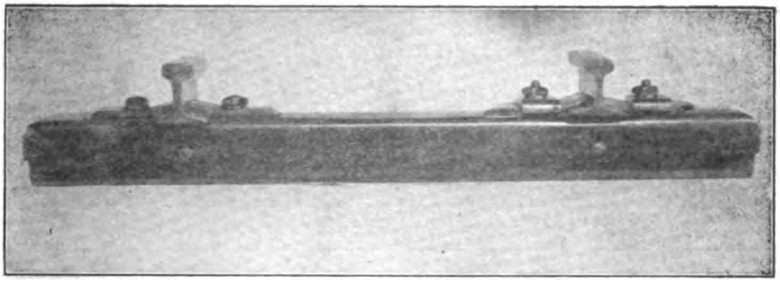


FIG. 17-b.

Fig. 17-b is a side view of the Snyder tie, showing two styles of rail fastenings or clips. The main feature in the clips is that they bear directly against the web of the rail and have no shoulder against flange of rail.

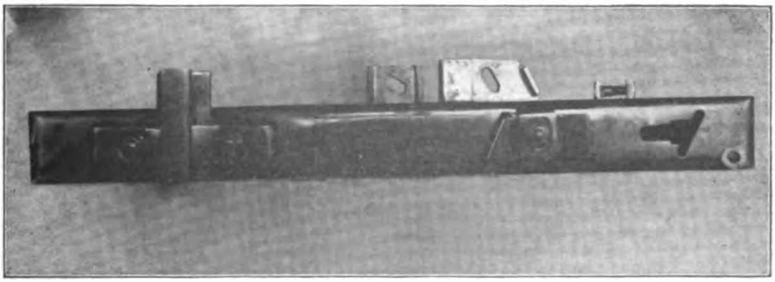


FIG. 17-c.

Fig. 17-c shows the top of the Snyder tie with one rail and one clip removed. The clips, bolt and washer show all the fastenings. The diagonal slot is shown plainly, which permits of narrowing or widening the gage slightly. The tenon or lug on the clip (marked

"4A" engages the tie in the diagonal slot and any side thrust is thus transmitted directly to the tie through the clip and does not bring the bolt into shear, as the end of the clip rests against web of rail.

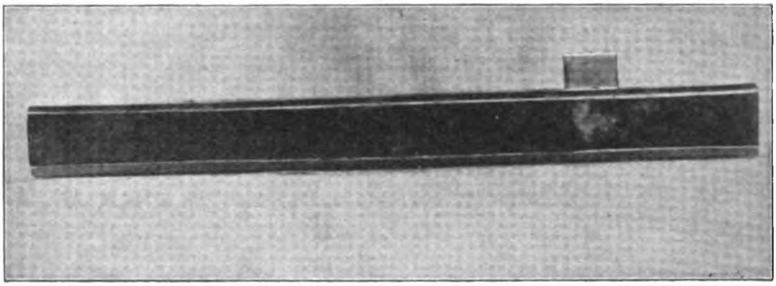


Fig. 17-d.

Fig. 17-d shows the bottom of the Snyder tie, with asphalt and stone filling coming in direct contact with the ballast.

So far the Snyder tie has given very satisfactory service in the yard tracks of the Pennsylvania Railroad at Conemaugh and Derry.

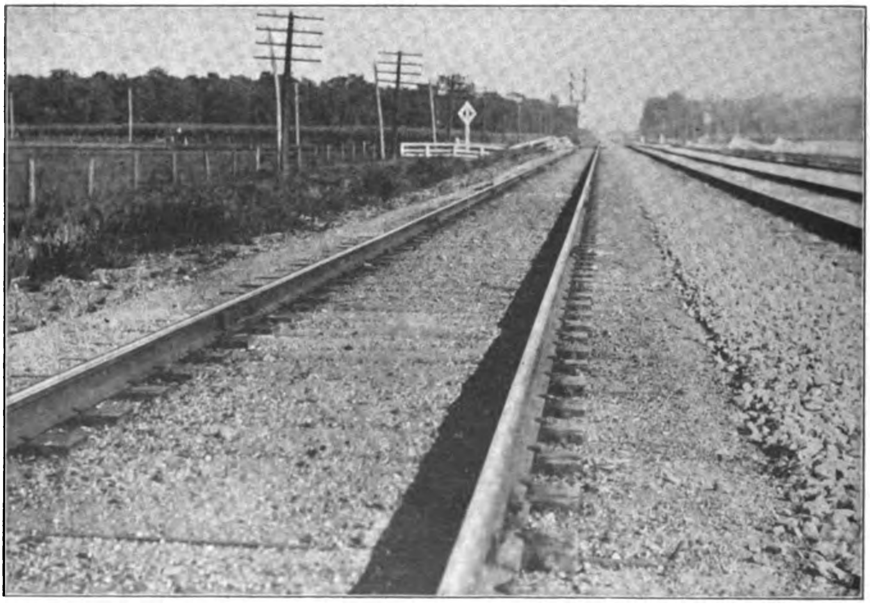


Fig. 18.

"B"—COMBINED WOOD AND STEEL TIE.

Fig. 18 shows the fourth or freight track of the Lake Shore & Michigan Southern Railroad, east of Toledo, tied with the Buhrer combined steel and wood tie. Early in 1907 the Carnegie Steel Ties on the Lake Shore & Michigan Southern Railroad were removed from the high-speed track. To care for the insulation the top flange of the tie was cut off and two wooden blocks bolted to the web of the tie for spiking strips and for the rail to rest on. These strips also rest on the bottom flange of the steel tie. Track was in good condition.

"C"—CONCRETE TIES.

Lake Shore & Michigan Southern Railroad.

Buhrer Concrete Tie.—Fig. 19 shows the Buhrer Concrete Ties in use on a nine-degree curve, located on the Cedar Point Pier branch at Sandusky, Ohio. About one mile of these were laid in 1904. The

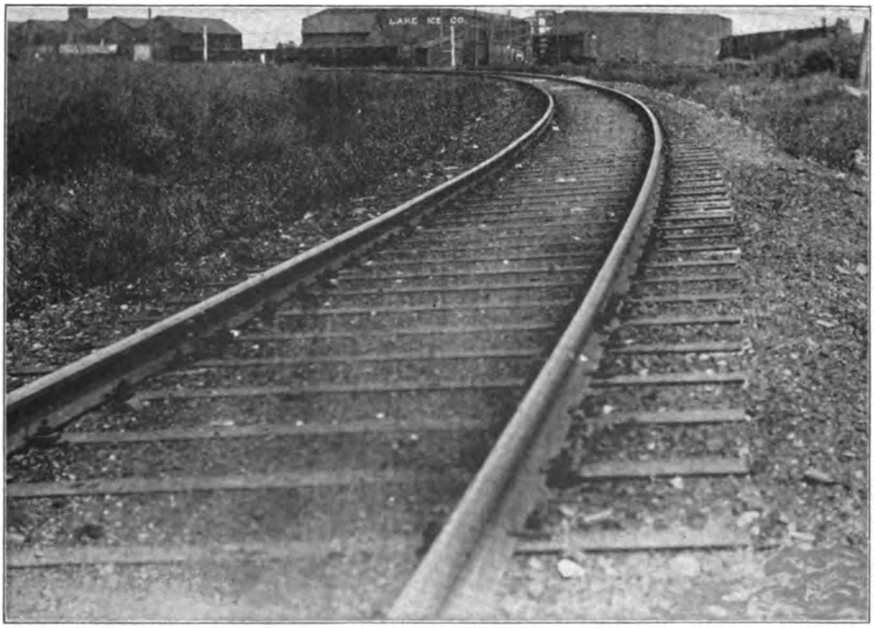


FIG. 19.

illustration indicates that the track is in first-class condition as to surface, gage, level and line. Clips, bolts, etc., were tight and the track foreman stated that they gave him much less trouble than the wood

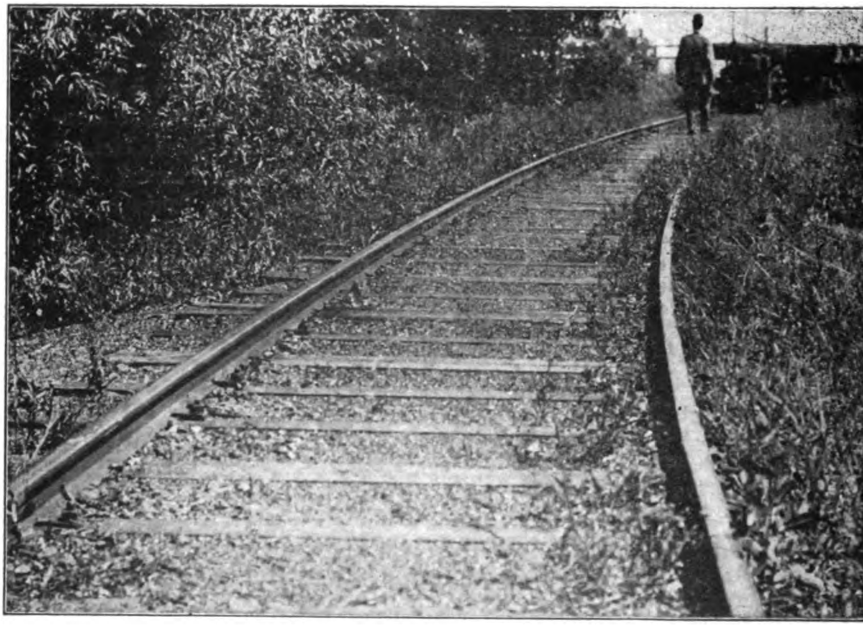


FIG 20.

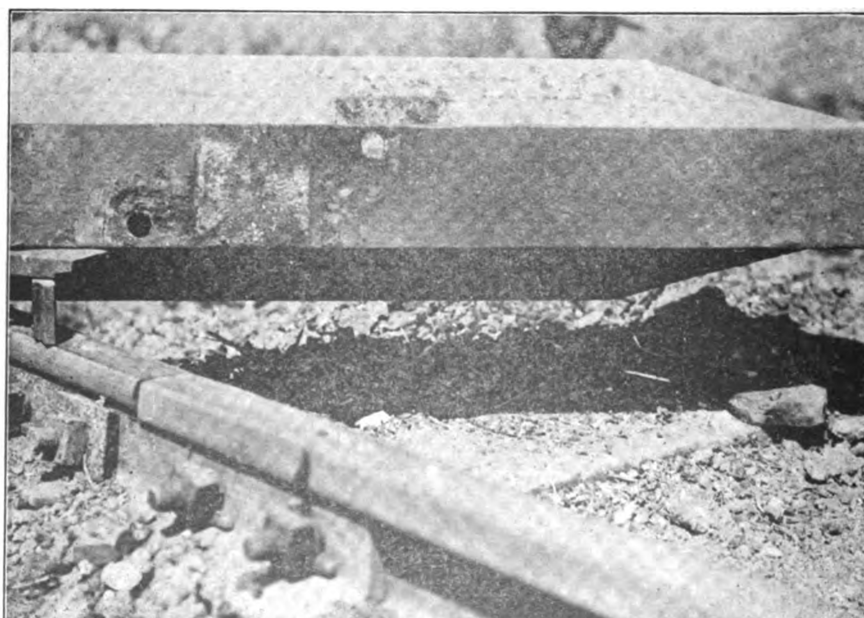


FIG. 21.

ties. There were no renewals up to September, 1908. The track is used for freight and excursion traffic. Heavy passenger engines use this track during the summer months. The track is ballasted with cinders.

Fig. 20 shows the Buhrer Concrete Ties and wood ties mixed on the Sandusky Water Works track. These have been in the track five years. Selected oak ties were laid at the same time the concrete ties were put in. At the present time fully one-third of the oak ties should be removed as they are badly decayed. The concrete ties are in first-class condition. Both the concrete and wood ties were ballasted with cinders.

Fig. 21 shows the face of a Buhrer Tie that had been in the above track five years. The top of the tie is very little, if any, rusted and the rail bearing shows scarcely any wear. Under the clip a little more rust was found; concrete was in perfect condition and showed no signs of cracking.

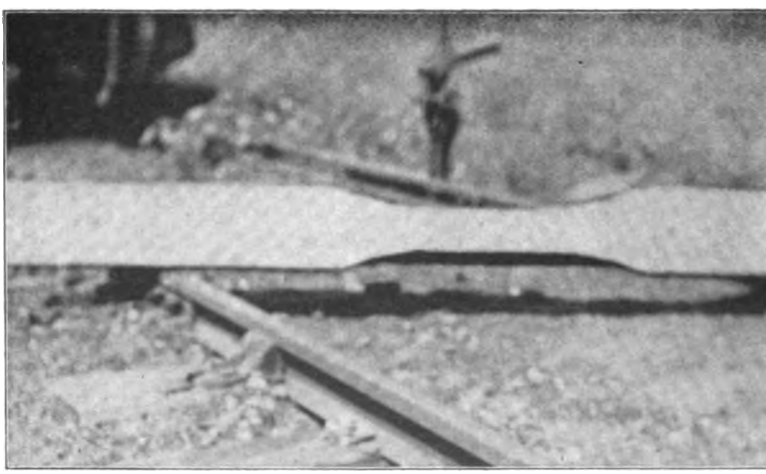


FIG. 22.

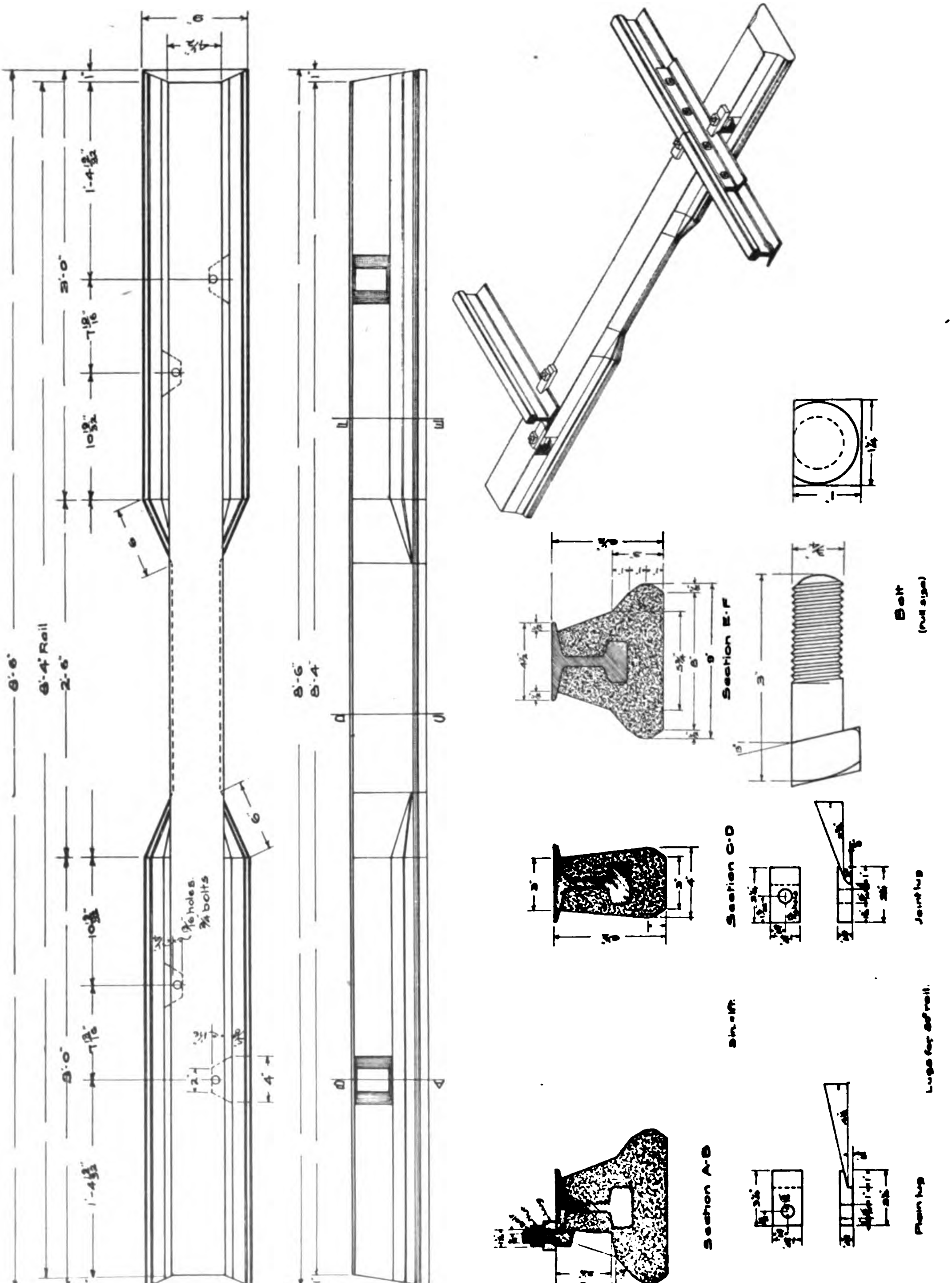
Fig. 22 shows the bottom or bearing surface of the above tie; also how the concrete is left out at center, which provides against side motion.

Fig. 23 is a side view of the above tie.

Pennsylvania Lines West of Pittsburg.

Fig. 24. About 600 of the Buhrer Concrete Ties were used on the Northwest System during 1903 and 1904, in stone ballast. Nearly 500 of these ties were subjected to heavy and high-speed traffic, and the balance to medium traffic.

The ties failed under traffic. The concrete breaking and crumbling



8'-6"
8'-4" Rail
2'-6"
3'-0"
9/16 holes
3/4 bolts
Section A-B
Section C-D
Section E-F
Bolt
(Full size)
Joint lug
Plain lug

FIG. 24.

off from the reinforcement. The ties were removed from time to time and by December, 1906, all of these ties had been removed on account of breaking.

Chicago Junction Railway.

The Chicago Junction people state that they put 19 Buhrer Ties into their track in 1904, and that they were removed after a few months' service on account of breaking.

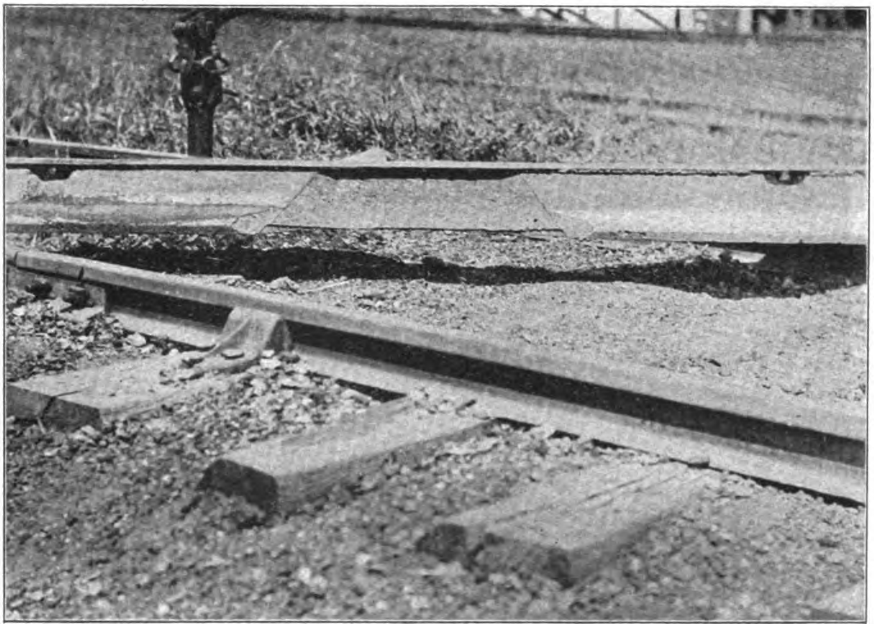


FIG. 23.

Lake Erie & Western Railroad.

Twenty-four Buhrer Concrete Ties were put into the track of the Lake Erie & Western Railroad during August, 1903. Seven ties have been removed on account of breaking. Ties laid in gravel ballast.

Chicago & Northwestern Railway.

Fifteen Buhrer Ties were put into Northwestern's north main track at Allis Station, Milwaukee, during August, 1902. These ties reported to be still in service and apparently in good condition.

"D"—KIMBALL TIE.

Fig. 25, 63 of these ties were put into the Chicago & Alton Railway's track (south bound) near Lockport, Ill., during October, 1905. Fig. 25 shows the ties in the track. The track was found to be in good condition, but several of the ties were cracked. Up to the present time they have given good service, holding the track to line and gage.

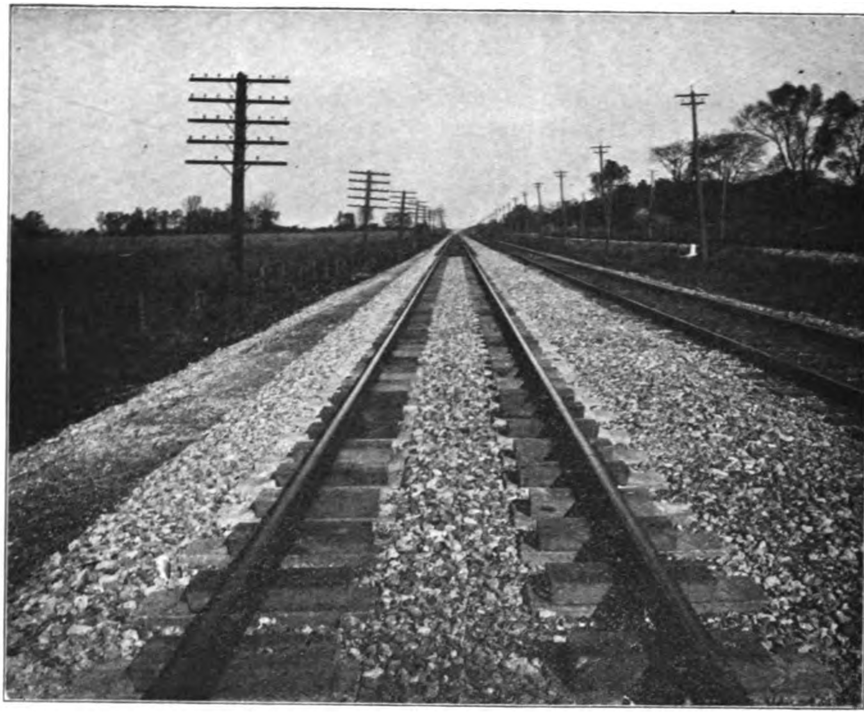


FIG. 25.

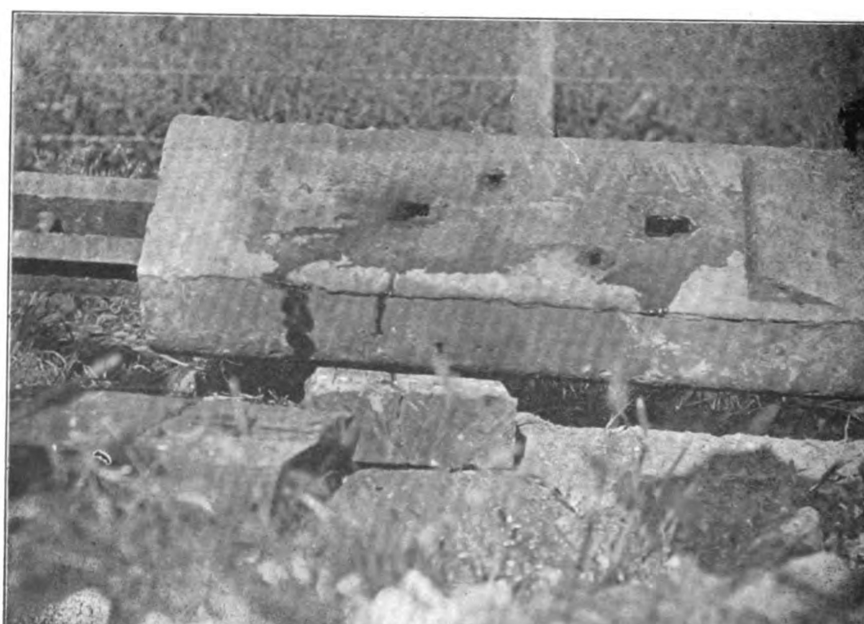


FIG. 26.

Eight of these ties had been removed on account of being badly cracked. Of the remaining ties the Committee found four ties with longitudinal cracks under the west rail. Under the east rail four were cracked longitudinally. The Committee also found cross cracks under the west and east rail, as follows: 15 ties were cracked crosswise under west rail, and 17 under east rail. To try and determine the cause of the cracked ties, the Committee took out two ties and removed the spiking block "A," Fig. 25, from several more ties. In every case we found that the plug in concrete had not been bored to receive the spike, and that in many cases the spike had partially or entirely missed the spiking plug, having been driven into the concrete.

Fig. 26 shows a tie in first-class condition taken from the track. In this tie the spikes entered the spiking plug at "B" and "C." Ties were not rusted to any extent in the center of the track between concrete ends.

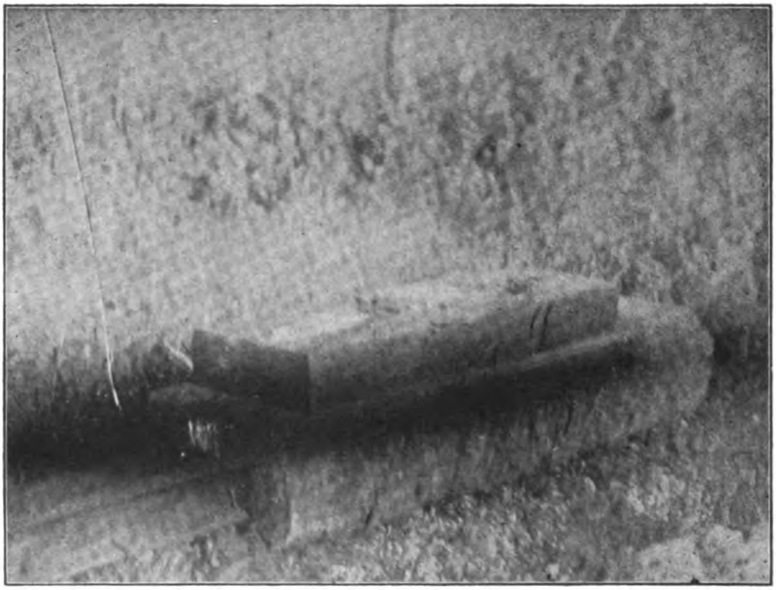


Fig. 27.

Fig. 27 shows a longitudinal crack at "A." This was the worst tie the Committee could pick out. When we took off the spiking block, we found the spike had been driven into the concrete.

The New York, Chicago & St. Louis Railroad has six of these ties in the main track and so far they have given good service. The failure of the ties at Lockport, in our minds, is due partly to application.

"E"—PERCIVAL CONCRETE TIE.

Figs. 28 and 29 show the Percival Concrete Ties which were in use on the Pittsburg & Lake Erie Railroad, for something less than two

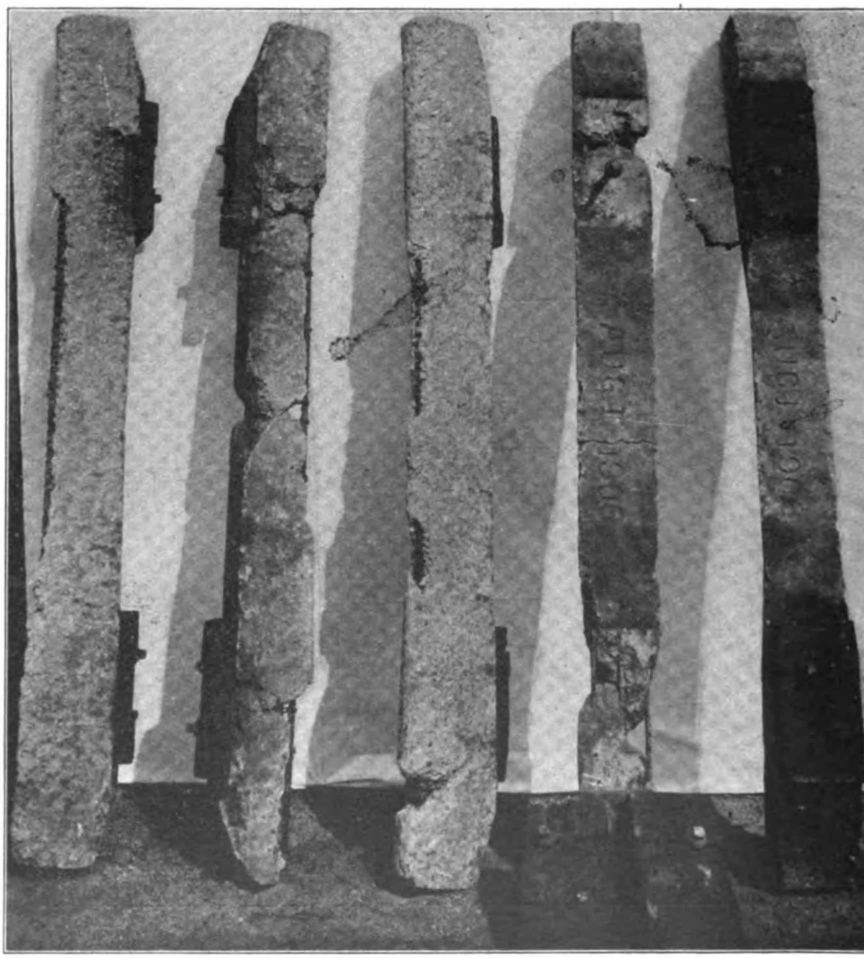


Fig. 28.

years. They were removed from the track during the summer of 1908, for the reason that the ties failed. The above figures illustrate very plainly how and where these ties failed.

"G"—AFFLECK CONCRETE STEEL TIE.

This is a reinforced concrete tie, 6x8 in., the reinforcement consisting of a three-inch I-beam. One hundred of these ties were placed in the main track near Emsworth, Pa., on the Pennsylvania Lines West of Pittsburg during October, 1904. These ties commenced to break almost immediately after having been put in the track; broken ties were removed from time to time, so that by April, 1905, none remained on account of being broken.

"H"—CHENOWETH CONCRETE TIE.

This is a reinforced concrete tie, the reinforcement consisting of a spiral roll of expanded metal. One hundred and one of these ties were put in track for a switching lead in Scully Yard, Pennsylvania Lines West of Pittsburg during December, 1906. The track was ballasted with cinders. Traffic is heavy with slow speed. Four ties removed prior to January, 1908, on account of crumbling under the rail. Of the 97 ties still in track 12 are crushed under the rail, 9 cracked near the rail and 13 cracked near the center of the tie.

"I"—KEEFER REINFORCED CONCRETE TIE.

Reinforcement consists of a number of steel rods. Forty-four of these ties were placed in No. 5 track, Scully Yard, on the Pennsylvania Lines West of Pittsburg during December, 1905. They commenced to break shortly after being put in and were removed as fast as they broke, so that by June, 1906, all had been removed on account of breakage.

"J"—HICKEY CONCRETE TIES.

These are built somewhat on the same lines as the Buhrer Tie, the reinforcement consisting of an old rail; 19 of them were placed in track on the Michigan Central Railroad some years ago. The Michigan Central people state that the ties were removed after two or three years' service on account of breaking.

"K"—THE ALFRED CONCRETE TIE.

About 100 of these ties were put in a freight track on the Pere Marquette Railroad in 1904. The Pere Marquette people report that ten of these ties were removed in 1908 on account of being broken under the rail.

"L"—SUNDRY OTHER FORMS.

Other forms of reinforced concrete ties have been tried with similar results as with the Keefer ties.

CONCLUSIONS.

The Committee's conclusions are as follows:

"A"—Steel Tie.

*An improved form of steel tie, as shown by Fig. 1, of the type manufactured by the Carnegie Steel Company, with metal plate over the insulating fiber, and with the wedge clip rail fastenings, seems to be very promising. Experiments with the same should be extended, and results carefully watched and reported to the Association.

"B"—Reinforced Concrete Tie.

(2) The Committee concludes that no form of reinforced concrete tie has been made which is suitable for heavy and high-speed traffic, but believes a properly reinforced concrete tie, with proper fastenings, may be found economical in places where speed is slow, and where conditions are especially adverse to life of wood or metal.

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*Amend to read: "Experiments with the steel tie should be extended and results carefully watched and reported to the Association."

DISCUSSION.

The President:—In the absence of the chairman and vice-chairman of the Committee, Mr. A. W. Thompson, of the Baltimore & Ohio, will present the report of the Committee.

Mr. A. W. Thompson (Baltimore & Ohio):—The report of the Committee on Ties is given in Bulletin 108, under three headings, namely, Compilation of Statistics, Timber Supply, and Metal Ties. I would suggest that the first subject, Compilation of Statistics, be taken up, and that the forms be carefully considered. In sending out proposed forms by the Sub-Committee and asking for suggestions, there were a great many different opinions, and these forms are a compromise. If they are adopted they would stand for a long time, as the data will be collected in accordance with the forms from which we will draw conclusions. If the forms are changed after some data are collected it will mean going back over the records and doing a great deal of work. If the forms are approved as recommended by the Committee, I think we should be prepared to hold the forms for a number of years, even though some discussion comes up as to proposed changes.

The Secretary:—"Your Committee recommends that Forms 1, 1-A, 1-B, 1-C and 1-D be withdrawn from the Manual and Forms M. W. 301, M. W. 302, M. W. 303, M. W. 304 and M. W. 305 be substituted."

Mr. L. C. Fritch (Illinois Central):—I would suggest to the Committee that Form M. W. 303, in the column marked "siding," be made "side," to be consistent with the other forms. "Siding" usually means a parallel track to the main track, used as a passing track. "Side" would conform to the other forms. That is simply a suggestion.

The President:—The Committee accepts that suggestion.

Mr. Fritch:—I notice in Form M. W. 304, Statistics of Treated Ties, that there is no column provided for oak. It is common to treat some classes of oak. I suppose that the blank column might be used for that if necessary.

Mr. Thompson:—The two blank columns were left for that purpose. We thought first of putting in one of the columns inferior oaks, having in mind red oak and some of that class. We also thought that with two blank columns and the columns headed as shown on the form, we should cover all the timber that would be treated.

The Secretary:—"That the conclusions of the Committee in reference to Timber Supply be approved."

Mr. Fritch:—I would suggest that the Committee's recommendation on that subject be read item by item.

The Secretary:—"(a) Use chemically treated ties wherever possible."

Mr. W. C. Cushing (Pennsylvania Lines):—I would suggest that the word "possible" be changed to "practicable." The matter of cost enters into the subject as to whether ties should be treated or not.

The President:—The Committee will accept that change.

The Secretary:—"(b) Protect such treated ties against mechanical wear by means of tie plates, screw spikes, etc."

Mr. Fritch:—I would suggest that all ties should be treated in the same way, that is, they should be protected in the same way; that the word "treated" ought to be omitted—"protect ties against mechanical wear by means of tie plates, etc."

The President:—You would omit the two words "screw spikes"?

Mr. Fritch:—Yes.

Mr. Thompson:—The reason "treated ties" were specified was on account of putting money into treatment, it was thought that everything possible should be done to further the life of the ties. In some parts of the country, where timber is cheap at the present time, it would not pay to put on tie plates, particularly on lines of light traffic.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—Do I understand that the adoption of conclusion 2 carries with it the recommendation of this Association that all ties are to be treated with tie plates and screw spikes and that screw spikes will take the place of ordinary spikes? It seems to me that is rather a radical departure and ought not to be passed over without some discussion.

Mr. Thompson:—I did not happen to be on the Sub-Committee on this subject. I would like to mention that the Committee here are agreeing to some changes that came up in discussion, and it is the minority members of the Committee that are agreeing to some of these changes. However, in regard to placing tie plates on all treated ties, there was considerable discussion. The conclusion of the Sub-Committee, as I understand it, was that if it paid to put additional money into treatment of ties, everything should be done to further the life of the ties.

Mr. Cushing:—I offer the following substitute for conclusion 2: "Protect all ties which wear out by mechanical wear with tie plates. In the case of treated ties the use of screw spikes should be considered as being possibly preferable to the common track spike."

Mr. Thompson:—I might add there, and call attention to, "protect such treated ties against mechanical wear." If we are going to permit the tie to wear out from mechanical wear or abrasion rather than decay, we reach a point where the treatment offsets the mechanical wear. If you can get additional life in the treated tie by using tie plates to offset the mechanical wear, it should be done.

Mr. Cushing:—That is very true, but it also applies to other ties which are destroyed by mechanical wear as well as to treated ties. It is a case of figuring out the relative cost to ascertain whether it is practicable to do so.

Mr. C. H. Ewing (Philadelphia & Reading):—Could Mr. Cushing's thought not be carried out by eliminating all the words after "mechanical wear"—"protect such treated ties against mechanical wear," leaving out the means of doing that?

Mr. Cushing:—I will accept that, Mr. President; let it stand that way.

The President:—The motion proposed by Mr. Cushing, seconded by Mr. Fritch, would read as follows: Conclusion 2—"protect all ties against mechanical wear."

Mr. McDonald:—On this question of screw spikes, I am very free to admit my preference for the use of screw spikes wherever expense has been incurred for treating the ties, but I have heard a number of objections to their use on account of the fact that it necessarily attaches the tie to the rail, and in case there is any lack of sufficient ballast underneath, the tie follows the rail up and down, whereas under the present arrangement the spike pulls out of the tie slightly, allowing the rail to move without disturbing the tie. What I would like to know is, does the Committee think the use of screw spikes on American roads has been tried to such an extent that they are warranted in recommending their use at this time?

Mr. Thompson:—No; I cannot say that the Committee has found that to be true. The use of screw spikes on American roads has been very limited, and in some of the tests which have been made the results have not been altogether satisfactory. I think Mr. Cushing would be willing to say something on that. He has investigated the subject very thoroughly, but from the data gathered from other countries as to the use of the screw spikes the results have not been very satisfactory.

Mr. Cushing:—I agree with Mr. McDonald. I do not think we are in a position at the present time to commit ourselves to an expression of an opinion so radical as suggested by the Committee. The screw spikes are being tried in this country in more or less large quantities, and that investigation should continue.

Mr. M. L. Byers (Missouri Pacific):—It seems to me that Mr. Cushing's motion hardly covers the case, because all ties are subject to mechanical wear, and if we attempt to protect all ties against mechanical wear we will be protecting ties which actually fail by decay. It seems to me that should read "protect all ties against *failure* from mechanical wear."

Mr. Cushing:—That is right, Mr. President.

Mr. J. A. Atwood (Pittsburg & Lake Erie):—I think the force of the second conclusion will be lost if Mr. Cushing's motion is carried. The force of the conclusion, it seems to me, is to call attention to the fact of the absolute necessity of protecting treated ties against mechanical wear, if you are going to get the value of the treatment.

Mr. Cushing:—I change my motion in accordance with the suggestion of Mr. Byers, "Protect all ties against failure from mechanical wear."

(Motion carried.)

The Secretary:—"(c) Enforce the tie specifications rigidly, with particular reference to the rigid exclusion of small ties."

Mr. Thompson:—I would suggest that the last "rigid" be left out of the second line.

The Secretary:—"(d) Co-operation among the roads in any given territory, looking toward the adoption of standard tie specifications, with particular reference to making it impossible for contractors to furnish ties cut from small trees, which would naturally form sources for future tie supplies.

"(e) Adopt measures for reducing forest fires.

"(f) Encourage the owners to re-forest their lands either by replanting or natural reproduction."

The President:—The chair would suggest that discussion on these matters be made a little more general. Experience has been that discussion in the past has generally been confined to more gentlemen in the front than at the back or ends of the room. Let me suggest to the gentlemen in the rear part of the hall that they take part in these discussions. They will feel better for it, and the Association will profit by it also.

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—Conclusion 6 is eminently proper. I was wondering what form of encouragement the Committee would suggest. How can we encourage owners to re-forest their land? It is very important that we should. It seems to me that the entire seven conclusions are eminently right and proper. The subject is one of immediate importance. There is an article in one of the March technical magazines which contains the statement that in parts of Germany cities derive a sufficient revenue from the sale of timber to pay the entire expenses of running these small cities. In other words, if this article states the facts correctly, there are no taxes in certain small cities in Germany, because the city owning the forest nearby derives a sufficient revenue from the matured timber to pay the entire expenses of the city. This whole question of re-forestry is one that needs further investigation on the part of this Association, and conclusion 6, it seems to me, should be dwelt upon at some future time in order to inform us in just what way re-forestry can be encouraged.

Mr. Thompson:—In answer to Mr. Wendt, I think one of the first things to do is to urge the railway managers to become the owners. Then your owner is right at hand and he is more accessible to encourage the development of land in the direction of forestry.

Mr. Fritch:—It seems to me that these suggestions properly belong to the committee that is co-operating with the National Conservation Commission, and, going a little ahead, I think that conclusion 7 rather goes into the domain of politics. I believe the province of this Committee is to treat of the technical side of the question and devise ways and means for increasing the life of ties. This question of re-forestation and assisting in securing favorable tax laws is a subject that should be referred to the other committee.

Mr. M. J. Henoch (Louisville & Nashville):—Is it too late to go back to the question of conclusion 3 with reference to timber supply, Appendix B? Has that been passed upon?

The President:—It has been passed upon. State your case, however.

Mr. Henoch:—I simply want to say, if we recommend the rigid enforcement of any one specification, is not that rather discrediting the other specifications? If any specifications are worth adopting at all, should not they all be enforced? It looks to me that if we put ourselves on record as enforcing one particular specification, it may be considered that we do not care about enforcing the others.

The President:—What do you mean? Specifications for buildings and all such?

Mr. Henoch:—No; specifications as to ties. The third conclusion says: "Enforce the tie specifications rigidly." Why should not all specifications be rigidly enforced instead of that one particular specification?

The President:—The way it is expressed makes it quite complete.

Prof. S. N. Williams (Cornell College):—While traveling in Minnesota and Wisconsin last summer I noticed much carelessness on railroads about fires started by locomotives. Apparently no precautions were taken to prevent these from extending to heavy timber. It was extremely dry and very necessary that fires should be promptly put out. I presume the great railway companies had such a regulation. I passed over one road, however, where no care seemed to be taken, and soon after great fires started in that vicinity which eventually caused losses in those states of over twenty million dollars. Conclusion 5 is important and can be enforced by instructions to trackmen. Conclusion 6 is also important but requires co-operation with the state or national government. Japan and Russia not only protect their forests, but Russia annually exports about thirty million dollars' worth of lumber. Some European governments are taking similar precautions. While not officially connected with any railway, I have recently investigated this subject and know how desirable it is for every citizen to assist in enforcing such measures as shall protect the country against the enormous losses which have been caused by fire in timber regions.

Mr. W. H. Hoyt (Duluth, Missabe & Northern):—I come from that region, in the northern part of the State of Minnesota, where we fought forest fires last summer, and I would like to state that at least one railroad spent a good many thousands of dollars and a good deal of time fighting these fires. We had 75 to 300 men fighting fire two or three weeks. Certainly in that region of the country it was a very important question, and I know that the other railroads in that part of the state did a great deal in the same line. In regard to conclusion 6, in our district there is at the present time one firm putting out 6,000 acres of Scotch spruce, replanting the land. They are importing these young trees from the old country, getting them in here in about their second year growth, just started, and are hand planting them on the cut-over lands, and the railroads are encouraging this by making a special effort to see that they are protected from fire. We keep our right-of-way cut once or twice every year, mowed down and burned, and if there is any sign of fire anywhere in the country our section gangs and bridge foremen have instructions to get after it without any delay, whether it is on the right-of-way or anywhere near

the right-of-way, started by the railroad or from any other cause. A year ago last summer we had occasion a number of times to send crews of men from our road for a mile or two into the country and take citizens and farmers from their homes and bring them into the open country and to help keep their trees from burning up. I think the recommendation made in conclusion 6 should stand as a proper encouragement for taking measures along that line.

Mr. Wm. L. Hall (Forest Service):—Mr. Chairman, is a visitor privileged to speak on this question?

The President:—Certainly.

Mr. Hall:—I should like to call attention to one or two points in connection with conclusions 5, 6 and 7 of the Committee. It seems to me that conclusions 5, 6 and 7 are virtually three sides of the same question. We are not to have effective measures of reducing forest fires unless at the same time we solve the question of forest land taxation; we are not to have effective re-forestation of lands, either by planting or by natural reproduction, unless we solve the tax question and the fire question. So it seems to me that these three questions are so intimately linked together as to be in reality only one. I suppose the adoption of these conclusions of the Committee now would be simply the adoption of the principles expressed in these three statements. It would not interfere with further work of the Committee along that line. I bring this point up for the reason that it seems that further work could properly be done. It is not enough to favor measures for protecting forests from fire and for encouragement of the growth in the abstract. We ought to know what plans have been found best fitted to carry out those purposes, what ends we can work to and what system we can adopt for those ends. There is a large field in that direction. Many methods have been worked out that have proved of value in various parts of the country for dealing with the question of taxation and the prevention or extinguishment of fires. Although much valuable work has been done, there is much further work to do on those questions. I hope the adoption of the Committee's conclusions will not have the effect of stopping the work, but that the Committee may go on into the questions more specifically in the future.

Mr. Chas. S. Churchill (Norfolk & Western):—Speaking on this same subject, conclusions 5, 6 and 7, I think there is some specific work that this Association can do in reference to conclusion 5 that follows out the practice that we find in Europe, through the Black Forest, and in this country, in some sections also, namely, cutting ditches alongside of the right-of-way, and even outside of the right-of-way, that are kept clean from all undergrowth in order that fire may not spread beyond the limits of control of the railway companies. Another feature that railroads can encourage is the easy means of furnishing a sale for the small timber that is left lying in the forests. Such a condition is never found in Europe. One never sees small timber lying around in the forests; it is always cut up and taken out of the forests and made use of. Those two points are live subjects that we, as railroad men,

can encourage. Speaking particularly to conclusions 6 and 7, we are voters, and as voters and members of railroad companies we can establish public opinion and back that opinion by our votes.

The Secretary:—"(g) Use the proper means to aid and assist in the investigation of tax laws as far as they pertain to forest lands with a view to having legislation enacted which would make it possible to hold lands with growing timber for the purpose of future tie production."

Mr. Thompson:—I move the adoption of that portion of the report of the Tie Committee.

Mr. J. B. Berry (Chicago, Rock Island & Pacific):—For the benefit of the Committee and quoting Mr. Thompson's remarks in regard to the failure of screw spikes, we made frequent examinations of their use and in every case where it was reported that they did not do their work we found it was the fault of installation. On the Rock Island we thought we issued good instructions in regard to the installation, but somebody else thought they knew how to do it better, and they put them in in their own way; the first reports we got were that they were failures. When we installed them as they should have been in the first place they did their work under trying conditions in first-class manner, so when we get reports of failures we had better find out whether they have been installed properly.

Mr. A. H. Rudd (Pennsylvania):—Before voting on this matter I would call attention to the fact that zinc or lead-treated ties seriously interfere with the track circuits for automatic signals. As a matter of information, it might be well, when defining what ties should be used, to state that there are certain chemically treated ties which seriously interfere with the proper working of the automatic signals.

Mr. Thompson:—The Committee does not recommend any specific treatment.

Mr. Ewing:—The matter brought up by Mr. Rudd is an important matter, and if there is anyone in the convention that has had experience along those lines I think it would be a material benefit to all of us to know something about it.

Mr. H. R. Safford (Illinois Central):—The Illinois Central has had some experience along this line with ties in track protected with automatic block signals. For the first year and a half after the installation of that system, which was installed at the same time the track was laid, we found the track circuits had to be shortened almost 50 per cent. It was our observation after the third or fourth year that we could have returned to the longer track—track circuit section—but not quite as long as we originally designed it, and it developed very plainly that with that character of ties there was some obstruction to the proper operation of the long track circuit.

The President:—The chair will now put the motion, that the conclusions of the timber supply section of the Tie Committee, as amended, be adopted.

(Motion carried.)

The Secretary:—"(3) That the following conclusions of the Committee in reference to Metal and Concrete Ties be endorsed:

"('*A*')—*Steel Tie*.—An improved form of steel tie, as shown by Fig. 1, of the type manufactured by the Carnegie Steel Company, with metal plate over the insulating fiber, and with the wedge clip rail fastenings, seems to be very promising. Experiments with the same should be extended and results carefully watched and reported to the Association."

Mr. Robert Trimble (Pennsylvania Lines):—It seems to me that this Association might word that conclusion a little differently. I understand that one of the things we are trying to steer clear of is that of being an advertising medium. It looks to me as if there was something of that nature in this conclusion. I do not believe it is policy to adopt it as it is now worded. By way of suggestion I would offer this modification: "An improved form of steel tie, as shown by Fig. 1, of the I-beam type, with metal plate over the insulating fiber," etc. I am not sure that I would want to recommend it, or that I would vote for it, but at the same time I think that is an improvement in the wording of the resolution.

The President:—That matter was up for discussion when the Committee were taking these points up, and the majority suggested the framing of the conclusion as given in the report, but if the point is well taken by Mr. Trimble, the Association should express itself upon it.

Mr. Trimble:—I move that it be so changed.

The President:—Will you read the clause as you would have it?

Mr. Trimble:—"An improved form of steel tie, as shown by Fig. 1, of the I-beam type, with metal plate over the insulating fiber, and with the wedge clip rail fastenings, seems to be promising. Experiments should be extended and results carefully watched and reported to the Association."

The President:—The chair cannot ask the Committee to accept that, because this is the minority. What is the sense of the meeting?

Mr. Joseph O. Osgood (Central Railroad of New Jersey):—I would suggest that it read, "an improved form of steel tie of the general type shown by Fig. 1, with metal plate," etc.

Mr. Rudd:—We still have our old friend, the track circuit, with us. That fiber insulation, as shown in Fig. 1, will last long enough to get it in—perhaps, a few minutes longer to take it out. I believe that we should add to the instructions that if experiments are made with these, they should be made with the track circuit also, because the track circuit, with automatic signals, is going to be increased in this country very appreciably, and it cannot be neglected and it cannot be operated successfully under any known conditions at the present time, where the circuit is so arranged that the signal will assume a stop position when the track is short-circuited by the wheels, if you also short-circuit it at every tie.

Mr. Atwood:—I would state that the Pittsburg & Lake Erie

Railroad has 3,000 I-beam steel ties in service. They have been in service nearly two years. They are insulated, and up to the present time there has been no difficulty on account of the insulation. They are as easily maintained as the wooden ties, and at no greater expense.

Mr. Rudd:—I would say that we installed, on the Pennsylvania Railroad, a section three-quarters of a mile long, of metal construction, with fiber insulation, and the first train that went over it cut out the insulations on some 40 or 50 ties, and we maintained this experimental track some six months, with the signals removed and orders that there was no automatic block on those tracks.

Mr. Thompson:—I should like to make a few remarks about steel ties on the Baltimore & Ohio. In doing this I want to apologize to some extent to the Committee who are absent. The experience of the Baltimore & Ohio in the use of steel ties of the I-beam type has not been as successful as that quoted by Mr. Atwood. Some of the points I would like to bring out forcibly is the movement of the steel ties of the I-beam type in the ballast. The ties skew around very badly, and in a mile section of this type of tie, compared with a mile section of the wooden tie, the cost of maintenance was very much in excess of the steel tie. Also, there must be taken into consideration (which the Committee has not included in its discussion) the additional quantity of ballast necessary with the I-beam tie. This is a very large factor, where the stone ballast is used, and where the cost per yard of stone ballast is very high, as in the East, it is very important. Another feature is the fastening, which, in this case, the manufacturers admit, could be improved. I think the best that can be done this year is to continue the observations of steel ties, as recommended by the Committee. No mention is made in the report of the damage occasioned to steel ties by derailment. On coal-carrying railroads, where there are steel cars of large capacity, broken flanges contribute to a large percentage of the derailments. In the test on the Baltimore & Ohio Railroad, where a derailment occurred from a broken flange, nearly all the ties in that immediate section were either destroyed or so badly damaged they had to be taken out of the track. The upper flange of the I-beam type, in a derailment, is usually very badly damaged. Another thing to be considered is the damage to the equipment. The flanges on all the wheels are either broken or chipped so badly that they have to be removed, which is not the case with the wooden tie.

Mr. Atwood:—Those 3,000 ties that we have in the track are on a slow-speed track.

Mr. Trimble:—We have had some experience with steel ties of the form recommended by the Committee, with the exception that we did not have the improved insulation referred to. When these steel ties were installed we had a great deal of difficulty with the insulation, which was originally wooden shims. These wore out very rapidly, and we found considerable interference with the track circuits, where automatic signals were in use, but after we changed from

wood to fiber we found less difficulty, and in the end practically no interference with the signals. But we did have a great deal of the same trouble complained of by Mr. Thompson. The trackmen continually complained about these ties moving the ballast. They were in stone ballast, and it was kept very well filled up, but not as full as it should have been, and in that respect the trackmen were a little delinquent; but we would line the ties up square with the rail, and inside of a week they would be out of line and irregular. Finally the trackmen had so much trouble with them that they took them out, however against the protest of the engineering department. On the whole, we had a great deal of difficulty with this style of tie. But at the present time I do not know of any better form of steel ties. Ties equipped in the manner referred to in this recommendation will be found to be very expensive, and I think we will find that there will be very few railroads that will be willing to pay the price. However, there is no objection to continuing experiments along this line, and I think the experiments ought to be made, but we ought to be very careful in regard to the wording of our conclusions.

Mr. E. R. Lewis (Michigan Central):—I have had several years' experience with steel ties on African railroads, where all the ties were of steel. We never had any trouble keeping them in line nor with track circuits, but we did have trouble with derailments. In case of derailment, a great many of the ties were often put out of commission.

Mr. Thompson:—The Bessemer & Lake Erie Railroad is the largest user of steel ties that I know of. They are, at the present time, using this I-beam type, I might say, almost exclusively. I do not know whether they have bought any wooden ties this year or not. They are making their renewals, putting the I-beam type of steel tie in, distributing them and making uniform renewals with the wooden ties. If there is a representative of the Bessemer & Lake Erie Railroad present, I suggest that he might say something.

Mr. F. R. Layng (Bessemer & Lake Erie):—We have about 90 miles of steel tie track under very heavy traffic. This year we are buying about thirty miles more. The sub-committee on steel ties made a trip over our road, and the report covers practically everything I might say. We are very much pleased with the steel ties and expect to use them on a still larger scale.

A Member:—I would like to ask if this recommendation is being considered for publication in the Manual?

The President:—No, sir.

Mr. Wendt:—I might say the increasing difficulty in connection with the purchase of wood ties makes it necessary to experiment with reference to a substitute tie. For that reason we, on the Pittsburg & Lake Erie Railroad, are conducting an experiment in this way: On the four-track road, two tracks are for high speed and two tracks for low speed, two for passenger trains and two for freight trains. We laid about one mile of steel ties and a similar

mile with wood ties, at one and the same time. The ties were new, that is, new wood ties were put in at the same time that the new steel ties were put in. New 90-lb. rails were laid at the same time. The track was completely ballasted at this same period, 12 inches of stone being used, in accordance with the recommendation of this Association. Track circuits are maintained within this limit. The speed of trains will average about 20 miles per hour at this point. For the first sixteen months trackmen were instructed to do no surfacing on either the steel ties or the wood ties. At the end of sixteen months we had the trackmen resurface both sections, and made a record of the expense. The expense in the meantime for the sixteen months was simply for patrolling and general supervision.

The results of the experiments are reassuring, and the labor expense is rather significant, so that we feel that the Committee is taking the right stand when it states in the last clause that experiments in steel ties should be extended and results carefully watched and reported to this Association. The best way to provide for the future maintenance of railroads, from the point of providing ties, is to use what we have at hand to-day and conduct systematic experiments with respect to a substitute tie, which will be forced upon us at some future time.

A Member:—What was the labor expense?

Mr. Wendt:—I do not like to go so far as to report the labor expenses in the proceedings, because our results were very favorable to the experiment. I shall not mention the figures at this time. We have the record at the end of sixteen months, and shall continue this experiment in the future, gathering our statistics from time to time, and when we have reached a point where the ties have been experimented with a sufficient length of time, we will then draw a conclusion which we think is warranted by the facts.

Mr. E. R. Lewis:—May I suggest that the experience, so far as I know, with steel ties is that they give very much better results in fine ballast than in coarse ballast; as a matter of fact, the finer the ballast, the better. A trough-shaped steel tie will remain in place better in sand than in ballast.

Prof. F. O. Dufour (University of Illinois):—I think the Committee should consult the results of European practice, at least in some respects. Of course, our loads and rolling stock are heavier than that of Europe, but we can at least learn that a tie of this form will shift very badly. It will not stand in a heavy ballast—rock ballast. As the last speaker said, the finer the ballast the better. From the results I have gathered abroad, and these are from a good part of the German Empire, I should say this tie would be one we should not use. I think the cost is prohibitive on account of the heavy section. It would be a bad tie to have in case of a derailment, and it will shift on the straight track, and on curves so badly that it should not be used at all. Any tie of this character which has a smooth surface throughout its entire length will shift. I saw

them taking up miles and miles of this very same general form. Not the I-beam form, but the form turning the other way, the channel form, and the foreman told me they shifted—I could see that for myself. They could not hold them in the ballast; and in case of a derailment they were very poor. What we need is some kind of a tie, I think, which will, while giving sufficient pressure, be so fixed that it cannot move sideways in the ballast and which will itself, in case of derailment, break up rather than injure the rolling stock to such an extent as this one surely will.

In regard to the fact that the tie will shift in the ballast and that you cannot hold it on a curve, I can assure you of that as the result of my observation of European practice. If they will shift in European practice, where light rolling stock is in use, what will they do here with our heavy loads and high speed?

Mr. Thompson:—I am sure that the Committee realizes that their report has not been gone into in an exhaustive manner; in fact, the data are not at hand to-day, and this is simply a conclusion of the Committee, and, therefore, I move that conclusion A be received as information.

Mr. L. C. Fritch:—I suggest to the Committee, as one of the important elements of this investigation, the traffic condition, both with regard to speed and the amount of traffic. A steel tie may perform very satisfactorily under slow speeds, but it may be a different question under high speed, and, therefore, it should be one of the elements to be considered in each case.

Mr. Cushing:—I wish to speak on the motion and offer an amendment. The amendment is that the first sentence be stricken out, and leaving the recommendation that experiments with the steel tie should be extended and results carefully watched and reported to the Association. We do not want to forget that conclusion 3, on page 152, is printed as if it were intended to go in the Manual, which is contrary to the intent of the Committee, as stated by the chairman.

(Motion, as amended, was carried.)

The Secretary:—"('B')—*Reinforced Concrete Tie.*—The Committee concludes that no form of reinforced concrete tie has been made which is suitable for heavy and high-speed traffic, but believes a properly reinforced concrete tie, with proper fastenings, may be found economical in places where speed is slow, and where conditions are specially adverse to life of wood or metal."

Mr. Cushing:—I move that it be adopted.

(Motion carried.)

Mr. L. C. Fritch:—I recommend that conclusion 3, on page 152, be changed to read: "That the conclusions of the Committee in reference to metal and concrete ties be received as information. I make that as a motion."

(Motion carried.)

The President:—We will excuse the Committee on Ties, with the thanks of the Association.

REPORT OF COMMITTEE NO. VII—ON WOODEN BRIDGES AND TRESTLES.

(Bulletin 107.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

The work assigned by the Board of Direction is indicated in the following outline:

(1) *Continue the revision of the specifications for structural timbers, co-operating with Committee Q of the American Society for Testing Materials and other committees on the subject, with a view, if possible, of preparing a uniform standard specification.*

(2) *Prepare a list of recommended safe unit stresses for structural timbers.*

(3) *Revise the report on standard names for structural timbers.*

(4) *Study the principles and methods of pile-driving, and collect data relating to the current practice.*

(5) *Report on best method for classification of pine timber for structural purposes in place of classification by botanical names.*

SUB-COMMITTEES.

The members of the Committee were divided among the following Sub-Committees on May 16, after some preliminary correspondence and personal conferences:

A. To consider Items 1, 3 and 5 in the outline of work: F. H. Bainbridge, *Chairman;* A. L. Bowman, H. S. Jacoby, F. B. Scheetz, C. C. Wentworth, B. A. Wood.

B. To consider Item 2: James Keys, *Chairman;* R. D. Coombs, L. J. Hotchkiss, Hans Ibsen, H. S. Jacoby, W. F. Steffens.

C. To consider Item 4: R. D. Coombs, *Chairman;* F. E. Bissell, Wm. Graham, H. S. Jacoby, Wm. Michel, W. F. Steffens.

COMMITTEE MEETINGS.

Three meetings of the Committee were held in Chicago, March 18, 19 and 20, 1908, at the time of the last annual convention, at two of which the continuation of work on Item 2 was considered, and general plans prepared regarding Item 4, preliminary arrangements being made to secure an early issue of the circulars of inquiry on present practice. The following members for the present year were in attendance: R. D. Coombs, Hans Ibsen, H. S. Jacoby, W. F. Steffens, B. A. Wood.

A meeting was held in Chicago on October 21, to review and perfect the reports of the Sub-Committees. The members present were: L. J. Hotchkiss, Hans Ibsen, H. S. Jacoby, James Keys, C. C. Wentworth and B. A. Wood. The morning and afternoon sessions were devoted to a consideration of safe unit stresses for structural timbers, and the evening session to piles and pile-driving.

Sub-Committee A held a joint meeting in Chicago on July 22, with representatives of the Yellow Pine Manufacturers' Association and of the American Society for Testing Materials, to adjust the remaining differences between the specifications for structural timbers adopted respectively by the three Associations. This meeting was attended by F. H. Bainbridge, H. S. Jacoby, F. B. Scheetz, C. C. Wentworth and B. A. Wood, of the Sub-Committee; by M. B. Nelson, A. H. Marburry and Wm. Cameron, of the Yellow Pine Manufacturers' Association; and by Dr. Hermann Von Schrenk and Dr. W. K. Hatt, of the American Society for Testing Materials.

Sub-Committee C held a meeting in New York on June 3, attended by R. D. Coombs and Wm. Graham; one in Atlantic City, on June 24, attended by R. D. Coombs and W. F. Steffens, and a third on September 2, in New York, at which R. D. Coombs and Wm. Graham were in attendance.

BRIEF REVIEW OF THE REPORT OF 1908.

Revised Specifications for Bridge and Trestle Timbers were submitted, together with a list of the differences between them and those of the American Society for Testing Materials. The Specifications for Piling were also revised and rearranged into tabular form for more convenient reference (see Proceedings, Vol. 9, pp. 317-319). For the reasons stated under the next topic this information was considered merely as a progress report.

The results of careful investigations on Wooden Trestle Bridges with Ballast Floors were placed on record. The report related to design, construction, and cost, as well as to their advantages and disadvantages as compared with the open-floor type (see Proceedings, Vol. 9, pp. 320-331). See also illustrations in Proceedings, Vol. 7, pp. 705-713. No action by the Association was required.

A progress report was presented on Safe Unit Stresses for Structural Timbers, including the results of an inquiry by circular letter to learn the current practice as to unit stresses used by the different railroads and to secure opinions on certain questions related to the work of the Committee. Most of the results were presented graphically (see Proceedings, Vol. 9, pp. 331-349).

A progress report was also submitted on the Preservation of Structural Timber, the investigations being preliminary to the preparation of specifications (see Proceedings, Vol. 9, pp. 350, 358). As a Standing Committee on Wood Preservation was created by the Board of Direction

at the time of the last convention, the above subject was transferred to the new Committee.

The report made the previous year on Standard Names for Structural Timbers was resubmitted, but at the request of the Committee final action was deferred for another year.

STANDARD SPECIFICATIONS FOR BRIDGE AND TRESTLE TIMBERS.

The recommended standard specifications now published in the Manual were adopted in 1906 (see Proceedings, Vol. 7, pp. 685, 715). After the convention the Board of Direction requested the Committee to "co-operate with the Committee on Structural Materials of the American Society for Testing Materials, with a view, if possible, to the preparation of a joint specification for structural timber." During the year numerous specifications were examined and compared, but no conclusion was reached (see Proceedings, Vol. 8, pp. 394, 395). The work was continued during the following year, but no complete agreement was reached by the two committees. In addition to the revised specifications, a list of differences still remaining to be adjusted was presented to the Association as a progress report for discussion and an expression of approval or disapproval to guide the Committee in future conferences (see Proceedings, Vol. 9, pp. 317, 361). At the January, 1908, meeting of the Yellow Pine Manufacturers' Association a committee was appointed to confer with the other two committees named above. Under the topic of Committee Meetings reference is made to the joint meeting of the three committees during the past year. The specifications as revised and adjusted are hereby presented for adoption. They may not appear to be entirely satisfactory to every member, but it is desirable to give them a fair trial, and if any provisions prove by experience to be unsatisfactory they may be modified subsequently by a joint conference of the committees.

The Specifications for Timber Piles have also been revised by Sub-Committee A to conform to the other Specifications for Timber, and have been materially simplified and condensed. They are also presented for adoption.

SAFE UNIT STRESSES.

The few unit stresses for structural timbers which are now published in the Manual of Recommended Practice were adopted in 1906 (see Proceedings, Vol. 7, pp. 694, 720, 721). At the same time nine abstracts of timber tests and of recommended unit stresses were published, most of them relating to longleaf yellow pine and Douglas fir (see Proceedings, Vol. 7, pp. 694-720).

In 1907 a bibliography of the tests of American structural timbers was given, which is supposed to be practically complete (see Proceedings, Vol. 8, pp. 409-416).

As indicated on a preceding page under a brief review of the report of 1908, the principal part of that report relating to unit stresses consisted of graphic representations on ten full-page diagrams of the unit stresses adopted in practice by the engineering departments of a large number of railroads. The diagrams facilitate comparison between individual values and indicate at a glance the range of practice. Those adopted in 1907 by the New York Central & Hudson River Railroad Company were printed in a separate table, as they were not received in time to be inserted on the diagrams (see Proceedings, Vol. 9, pp. 331-349).

The stresses recommended in Bulletin No. 12 of the U. S. Division of Forestry (1896) were reprinted, the values for longleaf pine, shortleaf pine, bald cypress and white oak being obtained from tests made by the Division of Forestry which were considered quite reliable. In addition the unit stresses adopted in 1895 by the American Association of Railway Superintendents of Bridges and Buildings and which have been extensively quoted and used were given as representing the results of a careful study of all data available at that time.

The report for this year includes a large number of diagrams showing the relation of lower to higher groups in the results of tests for various timbers, a comparison of certain older tests, mainly on full-size sticks, referred to in the bibliography previously published, and a table of safe unit stresses which are recommended for adoption by the Association. The principles relating to the determination of these unit stresses, various details connected with the tests on which they are based, and references to the unit stresses employed in practice are given in the body of the report.

The Committee acknowledges with grateful appreciation the courtesy of Prof. A. N. Talbot in granting permission to publish in the appendix an abstract of the results of a valuable series of tests of full-size stringers in advance of the regular publication in a bulletin of the Engineering Experiment Station of the University of Illinois. These results give important new information on the relation of longitudinal shear in beams to direct shear parallel to the grain in short blocks, and an interesting analysis of the influence of defects upon the stresses in the outer fibers as well as on the horizontal shear at the neutral surface.

PILES AND PILE DRIVING.

Two circulars, Nos. 104 and 105, were prepared by Sub-Committee C and sent in July to members of the Association and a selected list of other engineers and contractors. An analysis of the forty-seven replies received relating to a part of the questions is presented in this report, the data relating to the remaining questions being reserved for further study.

The only topic discussed is on "Overdriving Piles." The Com-

mittee regrets that it failed to receive a larger number of photographs or descriptions of overdriven piles where such have been found by later excavation or when withdrawn at the time of construction. It is to be hoped that anyone who sees this report and can thus render a real service to the profession will send the desired information to the Committee.

As an important aid to the thorough study of the subject of piles and pile-driving much time was spent in preparing the bibliography which is printed in subsequent pages. The references were selected from a larger number as containing information of value, and for convenient use are classified under suitable heads.

A series of definitions and a brief historical sketch of the subject are presented as an introduction. Those interested in the history and development may find a number of valuable references under that topic in the bibliography. Any criticisms or additions to the definitions, or additional references for the bibliography which may have been overlooked will be gratefully received.

CONCLUSIONS.

Your Committee recommends the adoption of the following conclusions:

(1) That the Standard Specifications for Bridge and Trestle Timbers be approved as good practice.

(2) That it is preferable to make the inspection of bridge and trestle timbers at the mills.

(3) That the Revised Specifications for Timber Piles be approved.

(4) That the list of Safe Unit Stresses for Structural Timber be approved.

Respectfully submitted,

Henry S. Jacoby, Professor of Bridge Engineering, Cornell University, Ithaca, N. Y., *Chairman.*

James Keys, Assistant Engineer, Union Pacific Railroad, Omaha, Neb., *Vice-Chairman.*

F. H. Bainbridge, Resident Engineer, Chicago & Northwestern Railway, Clinton, Iowa.

F. E. Bissell, Consulting Engineer, 2185 East 93d St., Cleveland, O.

A. L. Bowman, Consulting Engineer, 2611 City Investing Bldg., 165 Broadway, New York, N. Y.

R. D. Coombs, Structural Engineer, Pennsylvania Tunnel & Terminal Railroad, New York, N. Y.

William Graham, Assistant Bridge Engineer, New York, New Haven & Hartford Railroad, New Haven, Conn.

Hans Ibsen, Bridge Engineer, Michigan Central Railroad, Detroit, Mich.

F. B. Scheetz, Superintendent of Bridges, Missouri Pacific Railway, St. Louis, Mo.

W. F. Steffens, Engineer Bridges and Buildings, Carolina, Clinchfield & Ohio Railway, Johnson City, Tenn.

B. A. Wood, Resident Engineer, Mobile & Ohio Railroad, Mobile, Ala.

Committee.

The undersigned endorses the above report with the exception of the safe unit stresses, which, it is believed, should be reduced 10 per cent., since they are to be used without increasing the live load stresses for impact.

L. J. Hotchkiss, Assistant Bridge Engineer, Chicago, Burlington & Quincy Railway, Chicago, Ill.

The undersigned endorses above report, except as to Specifications for Longleaf Yellow Pine.

C. C. Wentworth, Principal Assistant Engineer, Norfolk & Western Railway, Roanoke, Va.

Appendix A.

*STANDARD SPECIFICATIONS FOR BRIDGE AND TRESTLE TIMBERS.

†(To be applied to solid members and not to composite members.)

General Requirements. ‡1. Except as noted, all timber shall be cut from sound trees, true and straight, and sawed standard size; shall be square edged, close grained, solid and out of wind; free from defects such as injurious ring shakes and crooked grain, unsound or loose knots, knots in groups, decay, large pitch pockets, or other defects that will materially impair its strength.

Standard Size of Sawed Timber. 2. Rough timbers sawed to standard size means that they shall not be over one-fourth (¼) in. scant from the actual size specified. For instance, a 12 in. by 12 in. timber shall measure not less than 11¾ by 11¾ in.

Standard Dressing of Sawed Timber. 3. Standard dressing means that not more than one-fourth (¼) in. shall be allowed for dressing each surface. For instance, a 12 in. by 12 in. timber after being dressed on four sides shall measure not less than 11½ in. by 11½ in.

NO. 1 R. R. GRADE. LONGLEAF YELLOW PINE AND DOUGLAS FIR.

Stringers. ¶4. Longleaf pine shall show not less than eighty-five (85) per cent. heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer, the average depth of sap shall not exceed one-half (½) in. Douglas fir shall show not less than ninety (90) per cent. heart as measured above. Knots greater than 1½ in. in diameter will not be permitted at any section within 4 in. of the edge of the piece.

Caps and Sills. 5. Shall show not less than eighty-five (85) per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece; to be free from knots over two and one-half (2½) in. in diameter.

Posts. 6. Shall show not less than seventy-five (75) per cent. heart on

*Amend heading to read: "Standard Specifications for Southern Yellow Pine Bridge and Trestle Timbers."

†Amend subheading to read: "(To be applied to single sticks and not to composite members.)"

‡Amend paragraph 1 to read: "1. Except as noted, all timber shall be sound, sawed to standard size, square edged, and straight; shall be close-grained and free from defects such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay or other defects that will materially impair its strength."

¶Amend paragraph 4 by omitting the sentence relating to Douglas fir and adding the following: "but knots shall in no case exceed four (4) in. in their largest diameter."

each of the four sides, measured across the sides anywhere in the length of the piece, and to be free from knots over two and one-half (2½) in. in diameter.

Longitudinal Struts or Girts.

*7. One face shall show all heart; the other face and two sides shall show not less than eighty-five (85) per cent. heart, measured across the face or sides anywhere in the length of the piece, and shall be free from knots one and one-half (1½) in. in diameter and over.

Longitudinal X Braces, Sash Braces and Sway Braces.

†8. Shall show four square edges and not less than eighty (80) per cent. heart on two faces, and shall be free from knots over one and one-half (1½) in. in diameter.

Ties and Guard Rails.

‡9. Shall show one face all heart; the other face and two sides shall show not less than seventy-five (75) per cent. heart, measured across the face or sides anywhere in the length of the piece; shall be free from knots over two and one-half (2½) in. in diameter, and where surfaced the remaining rough face shall show all heart.

[Since the specifications for structural timber arranged by joint conference do not contain any provisions regarding ties and guard rails, the preceding paragraph is added by the Committee.]

¶NO. 2. R. R. GRADE. LONGLEAF AND SHORTLEAF YELLOW PINE, DOUGLAS FIR AND WESTERN HEMLOCK.

Stringers.

§10. Shall be square edged, except that it may have one (1) in. wane on one corner. Knots shall not exceed in their largest diameter one-fourth (¼) the width of the face of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

Caps and Sills.

*11. Shall be square edged, with the exception of one (1) in. wane on one corner, or one-half (½) in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth (¼) of the width of the face of the stick in which they occur, and in no case

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*7. Longitudinal Struts or Girts.—One face shall show all heart; the other face and two sides shall show not less than eighty-five (85) per cent. heart, measured across the face or sides anywhere in the length of the piece, and shall be free from any large knots or other defects that will materially injure its strength.

†8. Longitudinal X Braces, Sash Braces and Sway Braces.—Shall show four square edges and not less than eighty (80) per cent. heart on each of two faces, and shall be free from any large knots or other defects that will materially injure its strength.

‡9. Ties and Guard Rails.—Shall show one face all heart; the other face and two sides shall show not less than seventy-five (75) per cent. heart, measured across the face or sides, anywhere in the length of the piece; shall be free from any large knots or other defects that will materially injure its strength.

¶Amend title to read: "R. R. Falsework Grade. Longleaf and Shortleaf Yellow Pine."

§10. Stringers.—Shall be square edged, except that it may have one (1) in. wane on one edge. Knots shall not exceed in their largest diameter one-fourth (¼) the width of the face of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

*11. Caps and Sills.—Shall be square edged with the exception of one (1) in. wane on one edge, or one-half (½) in. wane on two edges. Knots shall not exceed in their largest diameter one-fourth (¼) of the width of the face of the stick in which they occur, and in no case shall exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

shall exceed four (4) in. Ring shakes shall not extend over one-eighth (1/8) of the length of the piece.

†12. Shall be square edged, with the exception of one (1) in. wane on one corner, or one-half (1/2) in. wane on two corners. Knots must not exceed, in their largest diameter, one-fourth (1/4) of the width of the face of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not exceed over one-eighth (1/8) of the length of the piece. **Posts.**

‡13. Shall be square edged and sound and shall be free from knots one and one-half (1 1/2) in. in diameter and over. **Longitudinal Struts or Girts.**

¶14. Shall be square edged and sound and shall be free from knots two and one-half (2 1/2) in. in diameter and over. **Longitudinal X Braces, Sash Braces and Sway Braces.**

Explanatory Note for No. 1 R. R. Grade.

These specifications state the maximum limit of sap wood which will be accepted. In practice, with good inspection, the effect of these specifications should be to secure timber the bulk of which is practically all heart. In permanent bridge timber, not protected from decay, sap wood is not only useless in itself, but by furnishing a lodgment for the spores of fungi, it is the cause of starting and promoting the continuance of rot in the heart. Sap wood, especially after decay has set in, is also extremely susceptible to fire, while with precautions ordinarily exercised heart wood is practically immune from this source of danger.

On the other hand, for ordinary commercial purposes sap wood is as valuable as heart. Therefore, if the mill owners understand what is wanted, good heart timber can be obtained for a small advance in price over what is usually furnished, much of which contains in bulk 50 per cent. or more of sap wood.

To obtain proper results inspection should be made at the mills, where unsatisfactory timber can be rejected without hardship to the mill owner. Extensive buyers of timber should have inspectors stationed at the mills. To cover the needs of smaller buyers and municipalities, it seems that some of the established Inspection Companies might maintain an organization of timber inspectors at the mills, which would prove profitable to themselves, satisfactory to the mill owners and of incalculable benefit to those who use the timber.

SPECIFICATIONS FOR TIMBER PILES.

*NO. 1 R. R. GRADE.

†1. This grade includes white, burr and post oak, longleaf pine, Douglas fir, tamarack, Eastern white and red cedar, Western cedar, redwood and cypress.

---

†12. Posts.—Shall be square edged, with the exception of one (1) in. wane on one edge, or one-half (1/2) in. wane on two edges. Knots must not exceed, in their largest diameter, one-fourth (1/4) of the width of the face of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (1/8) of the length of the piece.

‡13. Longitudinal Struts or Girts.—Shall be square edged and sound, and shall be free from any large knots or other defects that will materially injure its strength.

¶14. Longitudinal X Braces, Sash Braces and Sway Braces.—Shall be square edged and sound, and shall be free from any large knots or other defects that will materially injure its strength.

*Amend title to read: "R. R. Heart Grade."

†1. This grade includes white, burr and post oak, longleaf pine, Douglas fir, tamarack, Eastern white and red cedar, chestnut, Western cedar, redwood and cypress.

2. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knots, decay or other defects, which may materially impair their strength or durability. In Eastern red or white cedar a small amount of heart rot at the butt, which does not materially injure the strength of the pile, will be allowed.

3. All piles must be butt cut above the ground swell and have a uniform taper from butt to tip. Short bends will not be allowed. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile.

4. Unless otherwise allowed, all piles must be cut when sap is down. All piles must be peeled soon after cutting. All knots shall be trimmed close to the body of the pile.

5. For round piles the minimum diameter at the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft.; eight (8) in. for lengths over thirty (30) ft. but not exceeding fifty (50) ft., and seven (7) in. for lengths over fifty (50) ft. The minimum diameter at one-quarter of the length from the butt shall be twelve (12) in. and the maximum diameter at the butt twenty (20) in.

6. For square piles the minimum width of any side at the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft.; eight (8) in. for lengths over thirty (30) ft. but not exceeding fifty (50) ft., and seven (7) in. for lengths over fifty (50) ft. The minimum width of any side at one-quarter of the length from the butt shall be twelve (12) in.

7. Square piles shall show at least eighty (80) per cent. heart on each side at any cross-section of the stick, and all round piles shall show at least ten and one-half (10½) in. diameter of heart at the butt.

*NO. 2 R. R. GRADE.

†8. This grade includes red and all other oaks not included in No. 1 R. R. grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine, or any sound timber that will stand driving.

9. The requirements for size of tip and butt, taper and lateral curvature are the same as for grade No. 1.

10. Unless otherwise specified piles need not be peeled.

11. No limits are specified as to the diameter or proportion of heart.

12. Piles which meet the requirements of grade No. 1 except the proportion of heart specified will be classed as No. 2.

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*Amend title to read: "R. R. Falsework Grade."

†8. This grade includes red and all other oaks not included in R. R. Heart grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine, or any sound timber that will stand driving.

Appendix B.

SAFE UNIT STRESSES.

The diagrams shown on sheets 13 to 18 inclusive, which accompany this report, give a summary of the average results for tests on full-size sticks of seven kinds of timber made during the past six years by the United States Forest Service in accordance with the instructions in Circular 38, published in 1906. Notes relating to the number of tests and the sizes of the sticks are given on each sheet. The results are classified to give the averages of groups of 10, 10, 30, 30, 10 and 10 per cent., respectively, and show their relation from the lowest to the highest group. The data from which these diagrams were prepared were furnished at the request of the Committee by the Office of the U. S. Forest Service on June 6, 1908.

The relation of the average value for the lowest 10 per cent. group to that of the general average for the entire series, expressed as a percentage for each kind of timber is as follows: Douglas fir, 62.8; Western hemlock, 80.3; Western larch, 71.8; Norway pine, 72.2; tamarack, 62.0; shortleaf yellow pine, 69.1; loblolly pine, 63.3; and the average for all the timbers is 68.2. When arranged according to the kinds of test the corresponding relations are as follows: Modulus of rupture, 61.2; modulus of elasticity, 69.3; shear parallel to the grain, 67.8; compression perpendicular to the grain, 69.3; and compression parallel to the grain, 74.9. The difference between the radial and the tangential shear is not large enough to require special consideration in determining safe unit stresses. The lowest single ratio is 46.5 per cent., being that for the modulus of rupture for Douglas fir which is partially air-dry. This value is 14 per cent. less than that of any other ratio and is clearly abnormal, since the average modulus of rupture for the lowest 10 per cent. group is 17 per cent. less for the partially air-dry than for the green timber, while that of the next higher 10 per cent. group is slightly larger, and the general average is over 5 per cent. greater.

The following statement to the Committee should be considered in comparing the average results for Douglas fir given on these sheets with those formerly published by the Forest Service: "The set of figures which was submitted by the Forest Service on June 6, 1908, was intended to show primarily the variation in strength from the average results shown in Circular 115. This set of results was obtained from material of a quality intermediate between merchantable and second, and the stresses are consequently somewhat lower than the average. The second row of figures represents a very fair average strength for mate-

rial of a merchantable grade. This grade as defined by the Pacific Coast Lumber Manufacturers' Association is a very good average grade for Douglas fir."

To facilitate comparison between average values and to indicate the range in some cases, the modulus of rupture, modulus of elasticity, and compression parallel to the grain, according to various authorities, are plotted on sheets 19 to 29 inclusive. Those relating to full-size beams or sticks require more especial consideration.

In communicating the data to the Committee the statement was made that "the tests of the Forest Service show that, as a rule, in structural timber the added strength of the wood fiber due to drying out is offset by seasoning defects, such as checks, shakes, etc., although in some cases, where the timber has been carefully dried under shelter, an increase of 20 per cent. in strength has been observed." In a later communication it was stated that "it has been found impossible to apply the moisture strength curves obtained from small specimens to structural sizes, since inherent defects in the material as well as seasoning defects have a very marked effect upon the strength of the material. Moreover, it has been found that the increase in strength due to seasoning varies with different grades, the greatest increase being in the select grades. The increase in strength due to seasoning varies in structural sizes from practically nothing to as much as 25 or 30 per cent., depending upon species, grades, and several other factors. As suggested in Circular 115, one cannot safely assume a larger working stress for air-dry material than for green material in large sizes."

Sheet No. 30 contains the table of ultimate and safe unit stresses recommended by the Committee. Unless otherwise stated the ultimate stresses are the average values for green timber. In cases where it was not possible to secure results for green timber in large sizes, those for partially air-dry timber are inserted in the table.

The average ultimate values for Douglas fir, shortleaf pine, Norway pine, tamarack, and Western hemlock were furnished by the U. S. Forest Service. As no recent tests on green longleaf pine in large sticks have been made, the Forest Service gave the following average values, expressed in pounds per square inch, for longleaf pine and Douglas fir, both being partially air-dry:

	Longleaf Pine.	Douglas Fir.
Modulus of rupture..................	7,160	6,876
Modulus of elasticity................	1,560,000	1,597,000
Shear parallel to the grain.........	(973)	770
Longitudinal shear in beams........	335	313
Compression perpendicular to grain at the elastic limit................	572	651
Compression parallel to grain.......	(4,800)	4,406

It was stated that "since the Georgia material, as shown in Circular 115, was of very excellent quality, being almost clear material, the fiber stresses are considerably above the average. The South Carolina material was of a good merchantable quality, and the values shown for

it may be considered very good averages." In the above table the values enclosed in parentheses are for the Georgia material (the corresponding ones for the South Carolina material not being given in Circular 115), and therefore require some reduction.

One set of values for green longleaf pine was computed so as to have the same relation to the stresses for green Douglas fir as the corresponding stresses bear to each other for the partially air-dry timbers. Another set of values was computed by applying the relation between the corresponding stresses for longleaf and shortleaf pine as given in Circular 15 of the Division of Forestry (1897). The mean of these two sets was then inserted in the table on sheet 30.

The average ultimate stresses for redwood are based on some tests made by L. E. Hunt in connection with the University of California. The results of the tests made in 1900 and 1901 are given in the appendix to this report. The tests of 1895 were published in Special Bulletin, No. 2, June 1, 1895, University of California, and reprinted in Berg's Timber Test Record.

The ultimate values for bald cypress were computed by comparison with those for longleaf and shortleaf pine, using the relations between these timbers for the respective stresses as given in Circular 15 (1897). Those for red cedar were derived in a similar manner by using the relations given in Bulletin No. 12 of the U. S. Division of Forestry (1896).

Most of the values for white pine, spruce and white oak are based on Lanza's tests of large-size sticks. The average values of the modulus of rupture and of the modulus of elasticity given on sheet 30 are obtained by considering only the beams having spans of 12 feet or over. When the beams with shorter spans are included the corresponding averages of the modulus of rupture are 4,451, 5,046, and 5,863; and of the modulus of elasticity 1,183,000, 1,332,500, and 1,131,000 pounds per square inch.

The ultimate shear parallel to the grain for white oak is taken from the Watertown tests and the compression parallel to the grain for white pine is taken from the same source. The elastic limit in compression perpendicular to the grain for white pine was obtained by comparison with longleaf and shortleaf pine, according to the relation given in Circular 15.

According to Circular 115 the ratio of the average elastic limit in bending to the average modulus of rupture when expressed as a percentage, is as follows: Douglas fir, 65.6; Western hemlock, 64.2; longleaf pine, 53.1; loblolly pine, 56.1; Norway pine, 64.1, and tamarack 61.6; the average for all the timbers being 60.8 per cent.

The corresponding ratios of the elastic limit to the ultimate strength in compression parallel to the fiber are as follows: Douglas Norway pine, 81.6, and tamarack, 74.1; the average for all the timbers

fir, 79.1; Western hemlock, 76.6; longleaf pine, 72.5; loblolly pine, 69.3; being 75.5 per cent.

In the recent tests of the U. S. Forest Service the elastic limit is found for compression on the side of the fiber or perpendicular to the grain. Formerly the compression was found for a deformation of 3 per cent. in the thickness of the stick as a guide to determine the safe stress. In examining the relation between the two methods it was found "that the elastic-limit strength of Western hemlock in side compression is about 71 per cent. of its strength at 3 per cent. deformation. The average elastic-limit deformation for the 30 tests in this summary was 1.09 per cent. The average elastic-limit deformation of 54 partly air-dry Southern pine specimens was but 0.55 per cent."

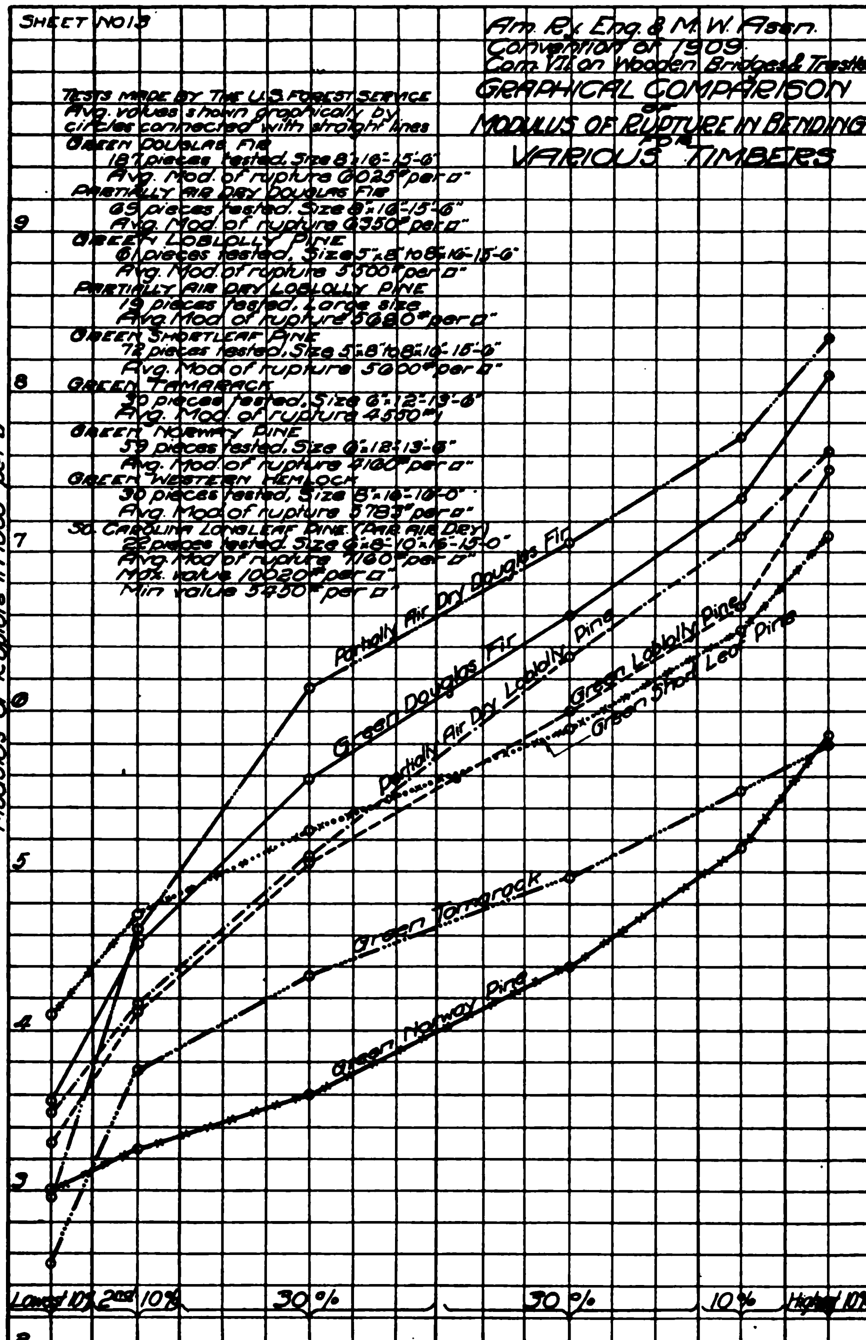
The safe unit stresses were determined by carefully considering both the average ultimate stresses, which represent the best results of tests now available, as well as the unit stresses which have been in use in designing wooden bridges and trestles, and have been demonstrated by extensive experience to be safe.

The relation between the strength of the lowest 10 per cent. group of tests and the average strength for each series, the relation between the elastic limit and the ultimate strength, as well as the fact that the live load stresses are not to be increased for impact, are all to be taken into account in determining the general relation between the safe stress and the average ultimate stress; it being always remembered that it is more rational to relate the safe unit stress to the elastic limit of the material than to its ultimate strength. When three sticks are used in one packed stringer it is improbable that all should have a relatively low strength.

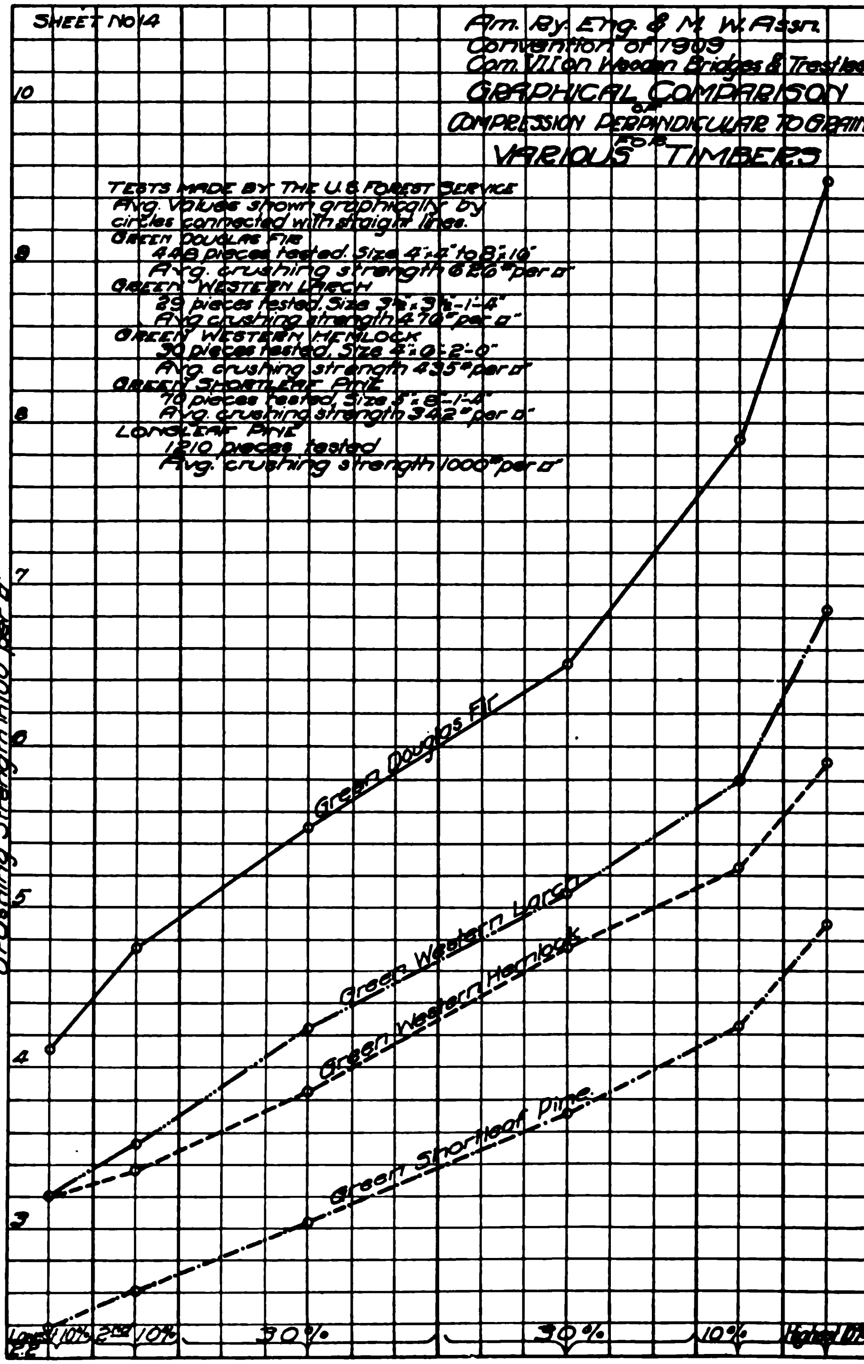
Since the average modulus of elasticity for the lowest 10 per cent. group is about 70 per cent. of the general average for any series it will be on the safe side to use this lower value in computing the deflection of a single stick, due to any temporarily applied static load; but for a load applied for a very long time, only one-half of the modulus of elasticity should be used in finding the deflection.

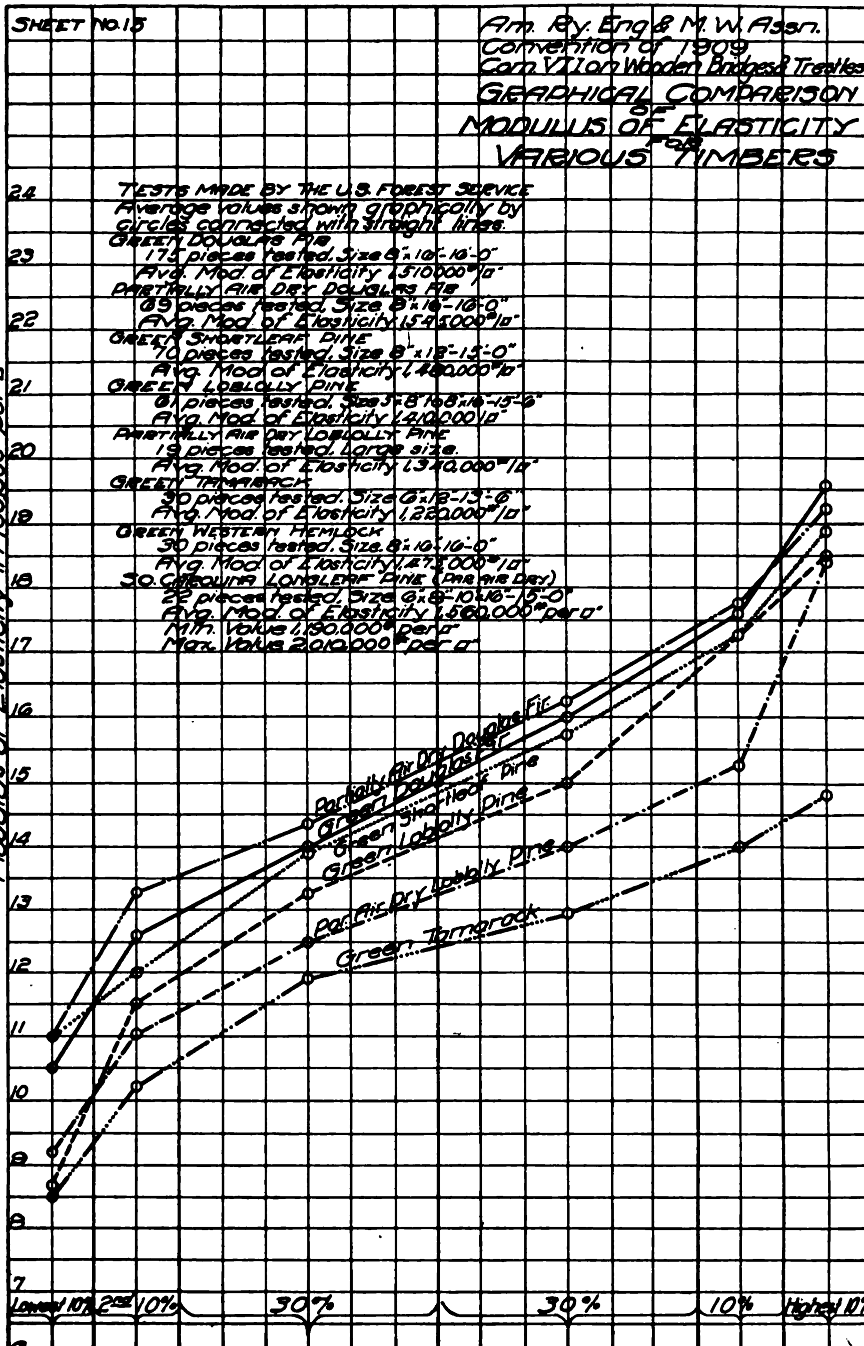
As large columns not over 15 diameters in length may not develop more than about 70 per cent. of the strength of short blocks, the column formulas are arranged to give approximately these relative values at the given limit of length when L the length of the column in inches equals 15 times its least diameter D, also expressed in inches. The formulas when plotted on a sheet give radiating straight lines.

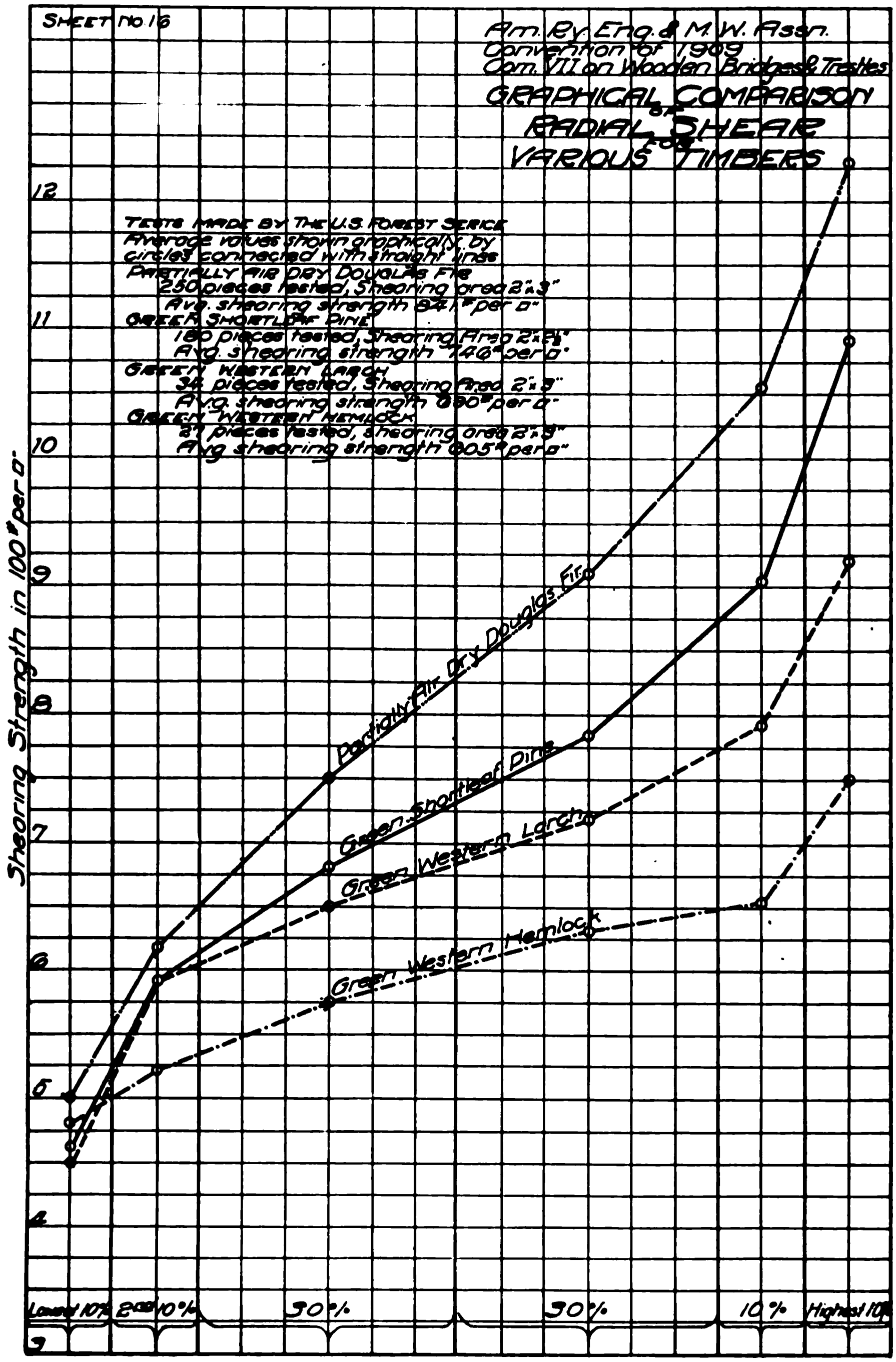
It is expected that these unit stresses will be revised at intervals of a few years, whenever new results of timber tests are published, or when the experience of bridge engineers who have adopted them shall indicate that revision is desirable.

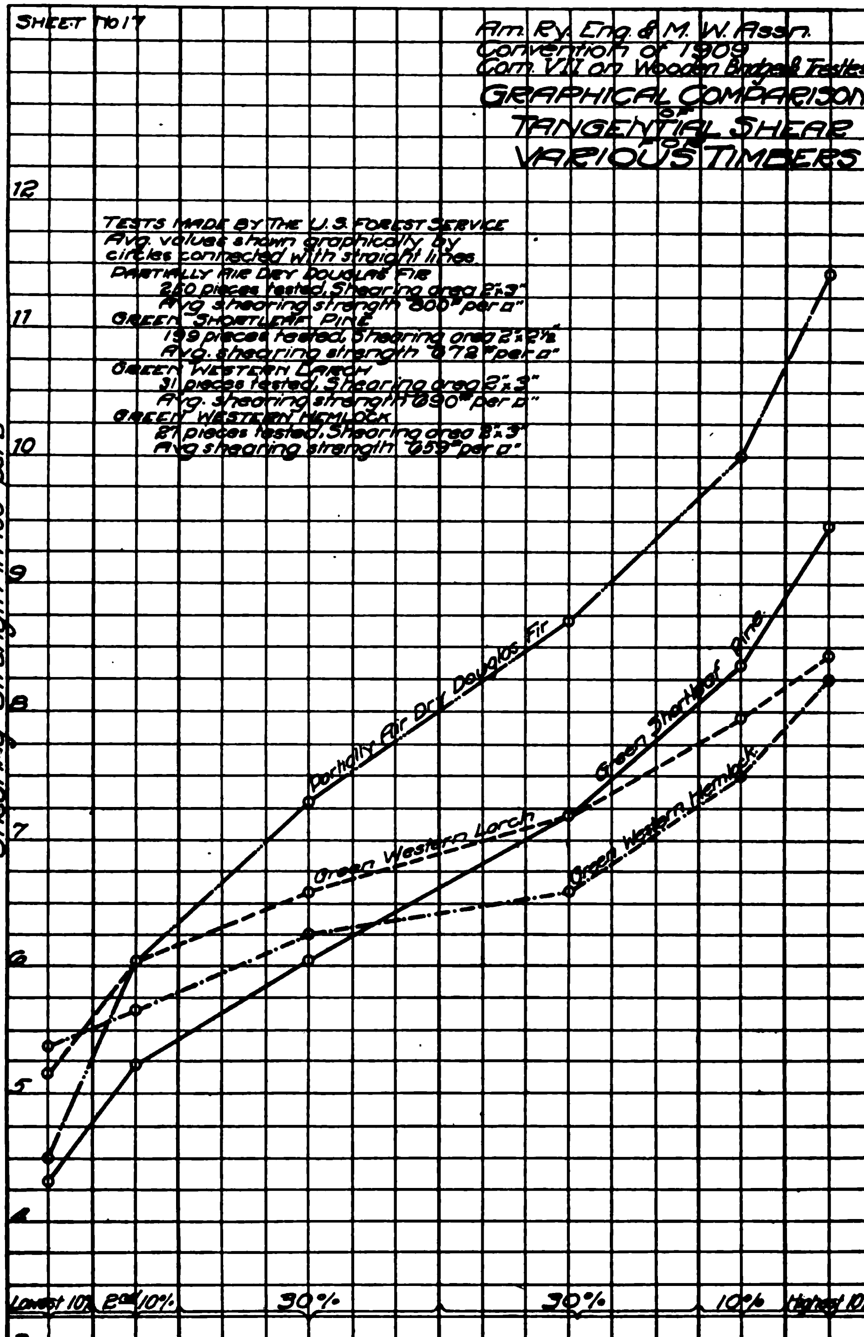


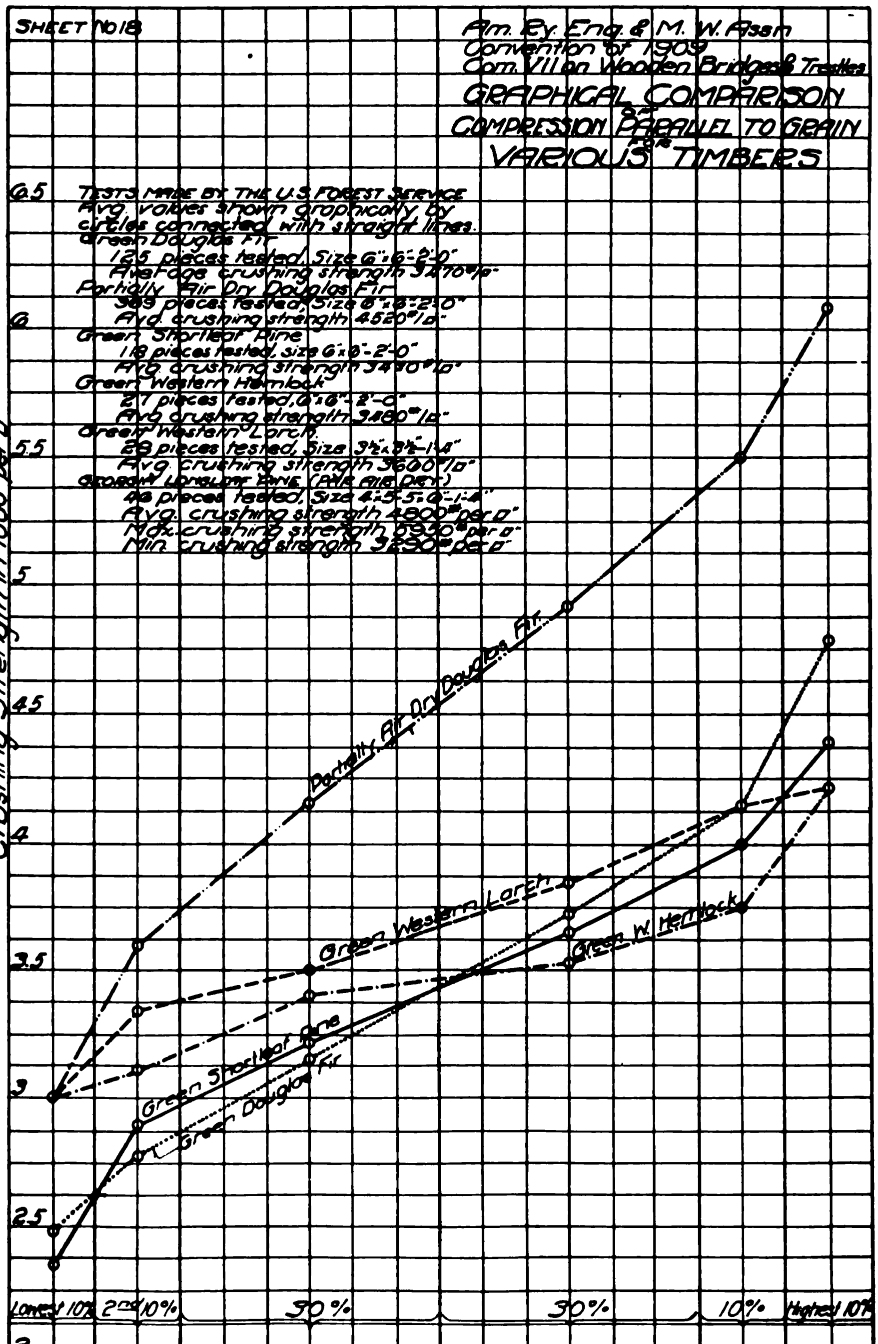
SHEET NO 13
Am. Ry. Eng. & M. W. Assn.
Convention of 1909.
Com. VII on Wooden Bridges & Trestles
GRAPHICAL COMPARISON
OF
MODULUS OF RUPTURE IN BENDING
FOR
VARIOUS TIMBERS
TESTS MADE BY THE U.S. FOREST SERVICE
Avg. values shown graphically by circles connected with straight lines
GREEN DOUGLAS FIR
187 pieces tested. Size 8"×16"-15'-6"
Avg. Mod. of rupture 6025# per □"
PARTIALLY AIR DRY DOUGLAS FIR
65 pieces tested. Size 8"×16"-15'-6"
Avg. Mod. of rupture 6350# per □"
GREEN LOBLOLLY PINE
61 pieces tested. Size 5"×8" to 8"×16"-15'-6"
Avg. Mod. of rupture 5300# per □"
PARTIALLY AIR DRY LOBLOLLY PINE
19 pieces tested. Large size
Avg. Mod. of rupture 5680# per □"
GREEN SHORTLEAF PINE
72 pieces tested. Size 5"×8" to 8"×16"-15'-6"
Avg. Mod. of rupture 5000# per □"
GREEN TAMARACK
30 pieces tested. Size 6"×12"-13'-6"
Avg. Mod. of rupture 4550#
GREEN NORWAY PINE
59 pieces tested. Size 6"×12"-13'-6"
Avg. Mod. of rupture 4100# per □"
GREEN WESTERN HEMLOCK
30 pieces tested. Size 8"×16"-16'-0"
Avg. Mod. of rupture 5783# per □"
SO. CAROLINA LONGLEAF PINE (PAR. AIR DRY)
22 pieces tested. Size 6"×8"-10"×16"-15'-0"
Avg. Mod of rupture 7160# per □"
Max. value 10020# per □"
Min value 3450# per □"
Modulus of Rupture in 1000# per □"
9
8
7
6
5
4
3
2
Partially Air Dry Douglas Fir
Green Douglas Fir
Partially Air Dry Loblolly Pine
Green Loblolly Pine
Green Short Leaf Pine
Green Tamarack
Green Norway Pine
Lowest 10%
2nd 10%
30%
30%
10%
Highest 10%


SHEET No 14
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII on Wooden Bridges & Trestles
GRAPHICAL COMPARISON
OF
COMPRESSION PERPENDICULAR TO GRAIN
FOR
VARIOUS TIMBERS
TESTS MADE BY THE U.S. FOREST SERVICE
Avg. Values shown graphically by circles connected with straight lines.
GREEN DOUGLAS FIR
448 pieces tested. Size 4"x4" to 8"x16"
Avg. crushing strength 626# per □"
GREEN WESTERN LARCH
29 pieces tested. Size 3½"x3½"-1'-4"
Avg. crushing strength 470# per □"
GREEN WESTERN HEMLOCK
30 pieces tested. Size 4"x0"-2'-0"
Avg. crushing strength 435# per □"
GREEN SHORTLEAF PINE
70 pieces tested. Size 5"x8"-1'-4"
Avg. crushing strength 342# per □"
LONGLEAF PINE
1210 pieces tested
Avg. crushing strength 1000# per □"
10
9
8
7
6
5
4
3
Crushing Strength in 100# per □"
Green Douglas Fir
Green Western Larch
Green Western Hemlock
Green Shortleaf Pine
10%
2nd 10%
30%
30%
10%

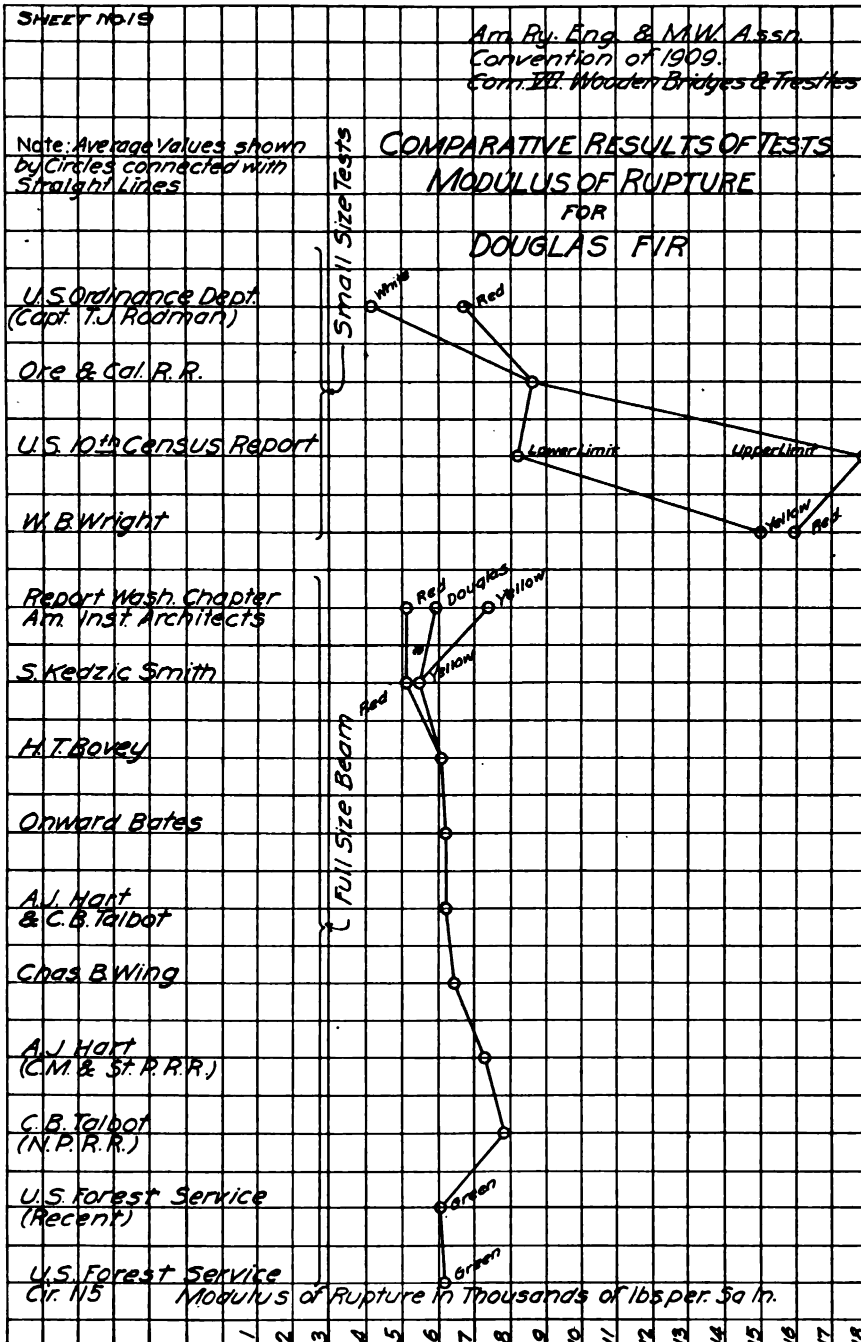

SHEET No. 15
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII on Wooden Bridges & Trestles
GRAPHICAL COMPARISON
OF
MODULUS OF ELASTICITY
FOR
VARIOUS TIMBERS
TESTS MADE BY THE U.S. FOREST SERVICE
Average values shown graphically by circles connected with straight lines.
GREEN DOUGLAS FIR
175 pieces tested. Size 8"x16"-16'-0"
Avg. Mod. of Elasticity 1,510,000#/□"
PARTIALLY AIR DRY DOUGLAS FIR
89 pieces tested. Size 8"x16"-16'-0"
Avg. Mod. of Elasticity 1,545,000#/□"
GREEN SHORTLEAF PINE
70 pieces tested. Size 8"x12"-15'-0"
Avg. Mod. of Elasticity 1,480,000#/□"
GREEN LOBLOLLY PINE
61 pieces tested. Size 5"x8" to 8"x16"-15'-0"
Avg. Mod. of Elasticity 1,410,000/□"
PARTIALLY AIR DRY LOBLOLLY PINE
19 pieces tested. Large size.
Avg. Mod. of Elasticity 1,340,000#/□"
GREEN TAMARACK
30 pieces tested. Size 6"x12"-13'-6"
Avg. Mod. of Elasticity 1,220,000#/□"
GREEN WESTERN HEMLOCK
30 pieces tested. Size 8"x16"-16'-0"
Avg. Mod. of Elasticity 1,475,000#/□"
SO. CAROLINA LONGLEAF PINE (PAR. AIR DRY)
22 pieces tested. Size 6"x8"-10"x16"-15'-0"
Avg. Mod. of Elasticity 1,560,000# per □"
Min. Value 1,190,000# per □"
Max. Value 2,010,000# per □"
Partially Air Dry Douglas Fir
Green Douglas Fir
Green Shortleaf Pine
Green Loblolly Pine
Par. Air Dry Loblolly Pine
Green Tamarack
Modulus of Elasticity in 100,000# per □"
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
Lowest 10%
2nd 10%
30%
30%
10%
Highest 10%

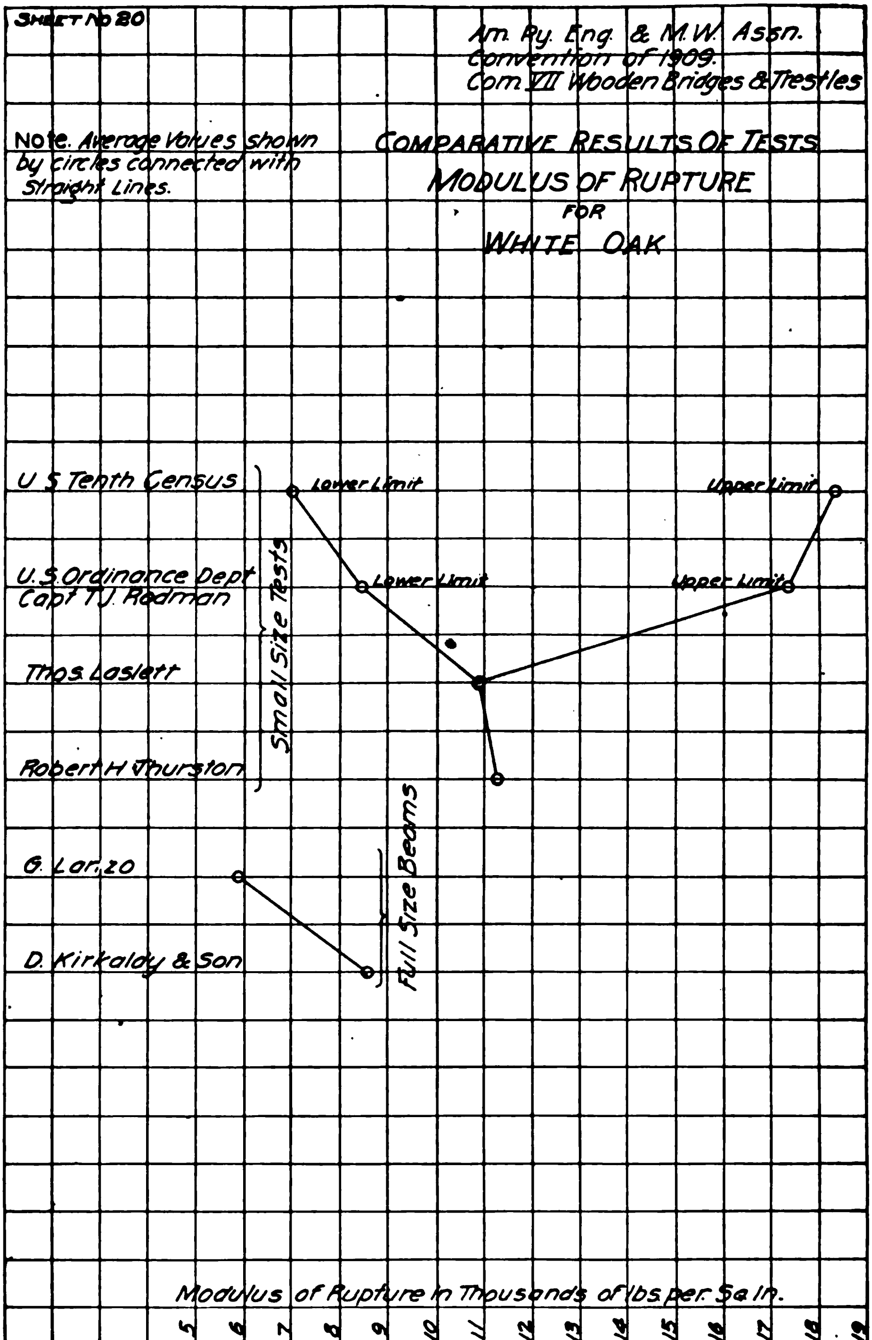

Sheet No. 16
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII on Wooden Bridges & Trestles
GRAPHICAL COMPARISON OF RADIAL SHEAR FOR VARIOUS TIMBERS
Tests made by the U.S. Forest Serice
Average values shown graphically by circles connected with straight lines
Partially Air Dry Douglas Fir
250 pieces tested, Shearing area 2"x3"
Avg. shearing strength 941# per □"
Green Shortleaf Pine
180 pieces tested, Shearing Area 2"x2½"
Avg. shearing strength 746# per □"
Green Western Larch
34 pieces tested, Shearing Area 2"x3"
Avg. shearing strength 690# per □"
Green Western Hemlock
27 pieces tested, shearing area 2"x3"
Avg. shearing strength 605# per □"
Shearing Strength in 100# per □"
12
11
10
9
8
7
6
5
4
Partially Air Dry Douglas Fir
Green Shortleaf Pine
Green Western Larch
Green Western Hemlock
Lowest 10%
2nd 10%
30%
30%
10%
Highest 10%

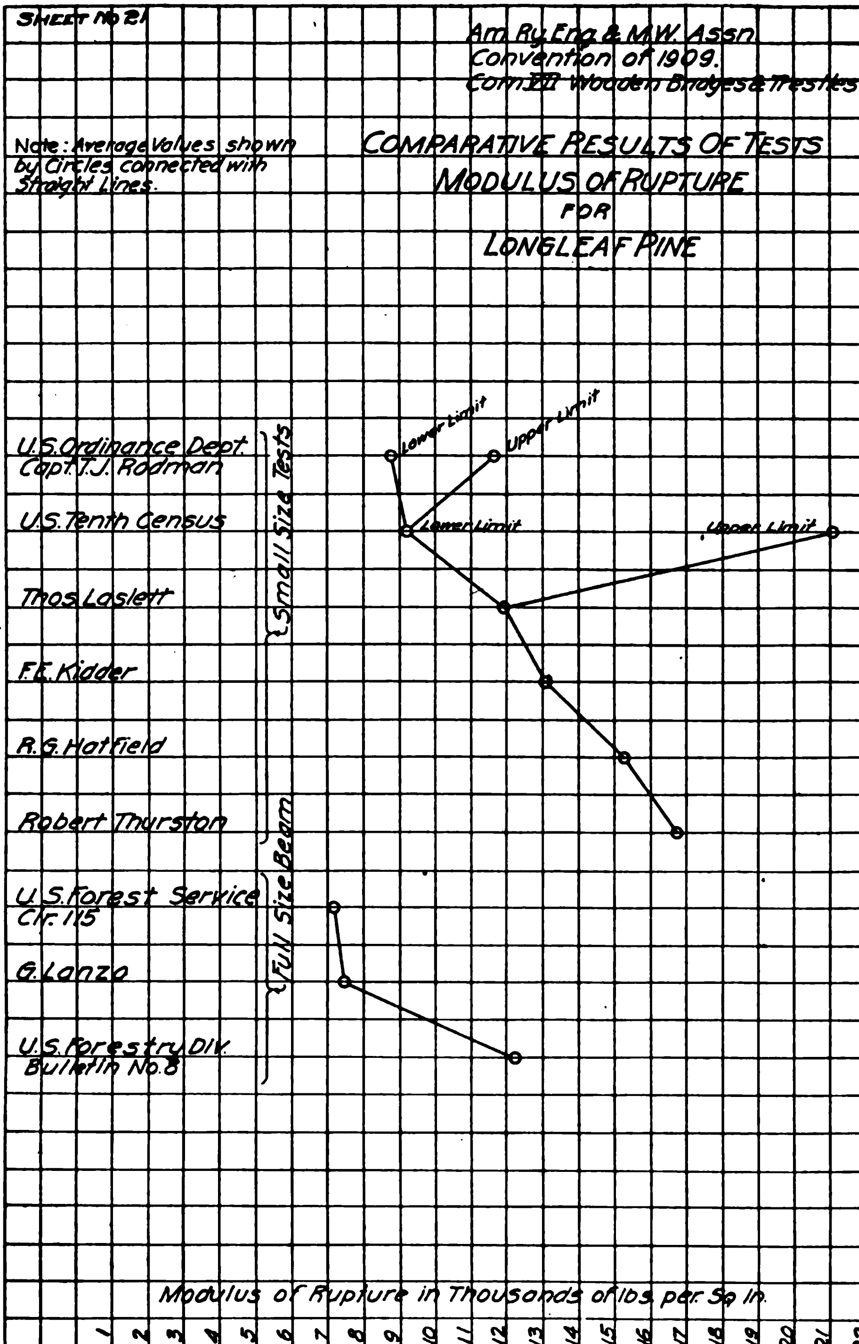

SHEET No 17
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII on Wooden Bridges & Trestles
GRAPHICAL COMPARISON OF TANGENTIAL SHEAR FOR VARIOUS TIMBERS
TESTS MADE BY THE U. S. FOREST SERVICE
Avg. values shown graphically by circles connected with straight lines.
PARTIALLY AIR DRY DOUGLAS FIR
250 pieces tested, Shearing area 2"x3"
Avg shearing strength 800# per □"
GREEN SHORTLEAF PINE
139 pieces tested, Shearing area 2"x2½"
Avg. shearing strength 672# per □"
GREEN WESTERN LARCH
31 pieces tested, Shearing area 2"x3"
Avg. shearing strength 690# per □"
GREEN WESTERN HEMLOCK
27 pieces tested, Shearing area 2"x3"
Avg shearing strength 659# per □"
Shearing Strength in 100# per □"
12
11
10
9
8
7
6
5
4
Partially Air Dry Douglas Fir
Green Shortleaf Pine
Green Western Larch
Green Western Hemlock
Lowest 10%
2nd 10%
30%
30%
10%
Highest 10%

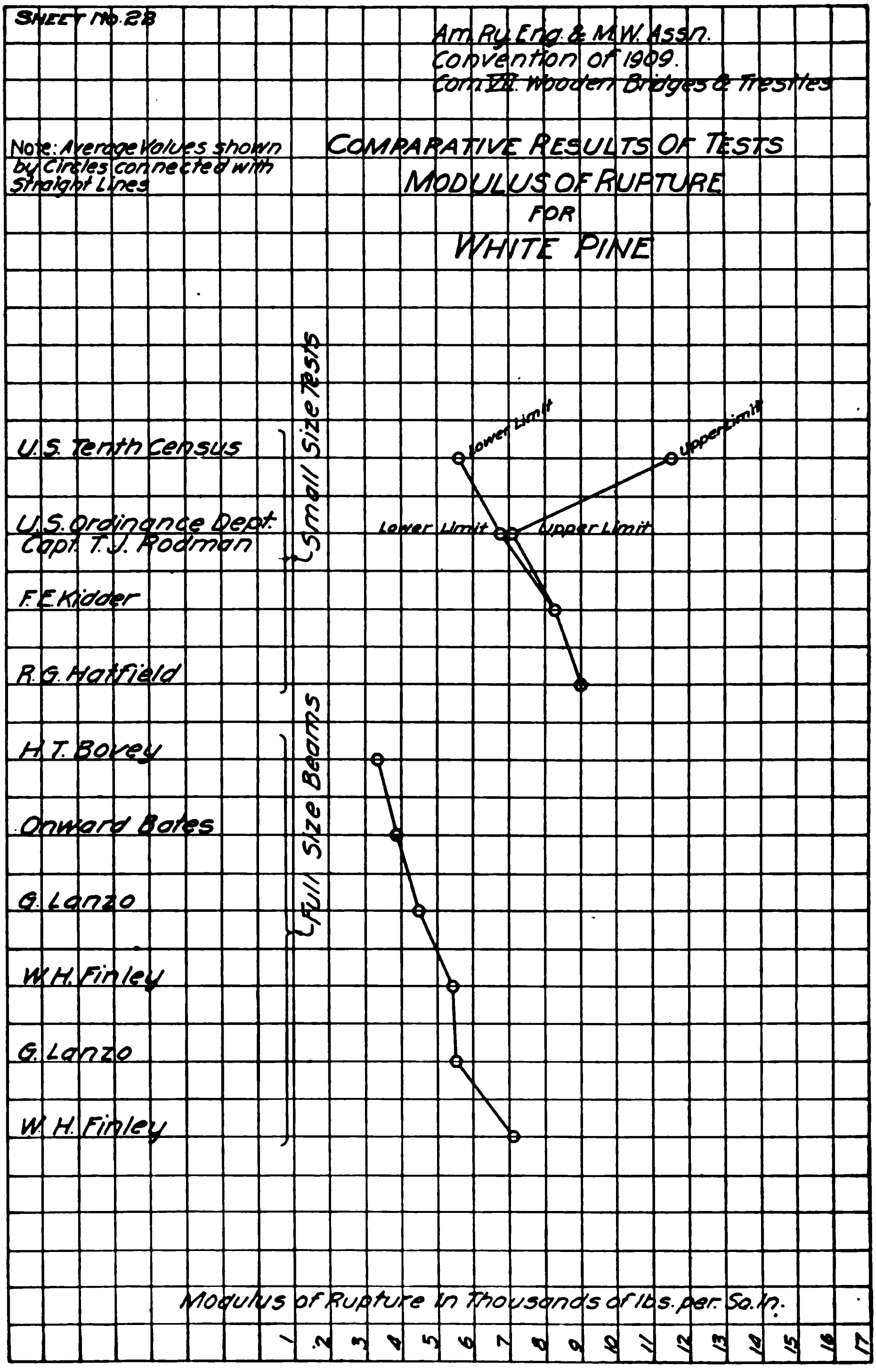


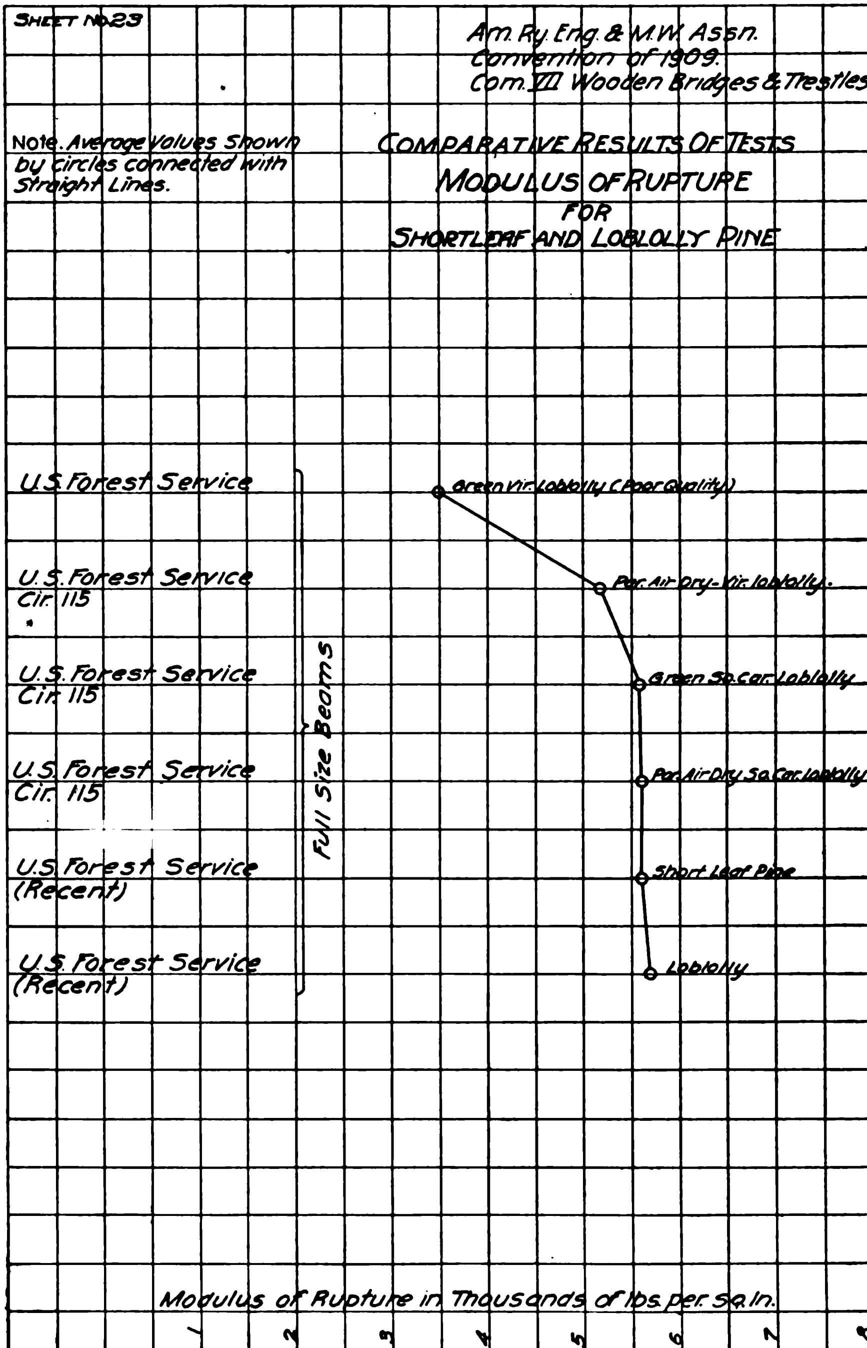
SHEET No 18
Am. Ry. Eng. & M. W. Assn
Convention of 1909
Com. VII on Wooden Bridges & Trestles
GRAPHICAL COMPARISON
OF
COMPRESSION PARALLEL TO GRAIN
FOR
VARIOUS TIMBERS
TESTS MADE BY THE U.S. FOREST SERVICE
Avg. values shown graphically by circles connected with straight lines.
Green Douglas Fir
125 pieces tested, Size 6"×6"-2'-0"
Average crushing strength 3270#/□"
Partially Air Dry Douglas Fir
389 pieces tested, Size 6"×6"-2'-0"
Avg. crushing strength 4520#/□"
Green Shortleaf Pine
118 pieces tested, size 6"×6"-2'-0"
Avg. crushing strength 3490#/□"
Green Western Hemlock
27 pieces tested, 6"×6"-2'-0"
Avg. crushing strength 3380#/□"
Green Western Larch
28 pieces tested, Size 3½"×3½"-1'-4"
Avg. crushing strength 3600#/□"
Georgia Longleaf Pine (Air Dry)
48 pieces tested, Size 4"-5"-5"-6"-1'-4"
Avg. crushing strength 4800# per □"
Max. crushing strength 6930# per □"
Min. crushing strength 3290# per □"
Crushing Strength in 1000# per □"
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
Partially Air Dry Douglas Fir
Green Western Larch
Green W. Hemlock
Green Shortleaf Pine
Green Douglas Fir
Lowest 10%
2nd 10%
30%
30%
10%
Highest 10%

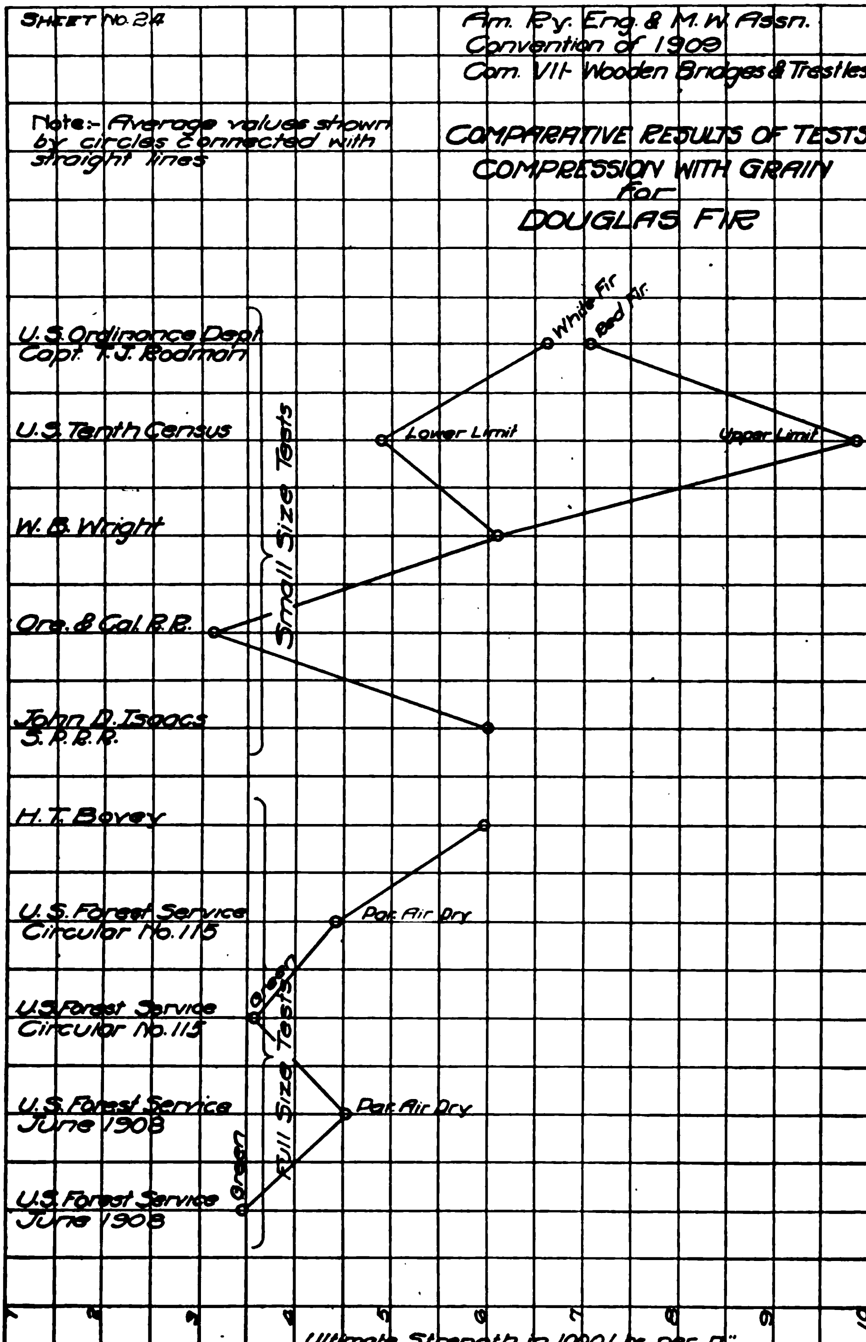

Sheet No. 19
Am. Ry. Eng. & M.W. Assn.
Convention of 1909.
Com. VII. Wooden Bridges & Trestles
Note: Average Values shown by Circles connected with Straight Lines
COMPARATIVE RESULTS OF TESTS
MODULUS OF RUPTURE
FOR
DOUGLAS FIR
Small Size Tests
U.S. Ordnance Dept. (Capt. T.J. Rodman)
White
Red
Ore & Cal. R.R.
U.S. 10th Census Report
Lower Limit
Upper Limit
W. B. Wright
Yellow
Red
Full Size Beam
Report Wash. Chapter Am. Inst. Architects
Red
Douglas
Yellow
S. Kedzie Smith
Yellow
Red
H. T. Bovey
Onward Bates
A.J. Hart & C.B. Talbot
Chas. B. Wing
A.J. Hart (C.M. & St. P. R.R.)
C.B. Talbot (N.P. R.R.)
U.S. Forest Service (Recent)
Green
U.S. Forest Service Cir. 115
Green
Modulus of Rupture in Thousands of lbs per Sq. In.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

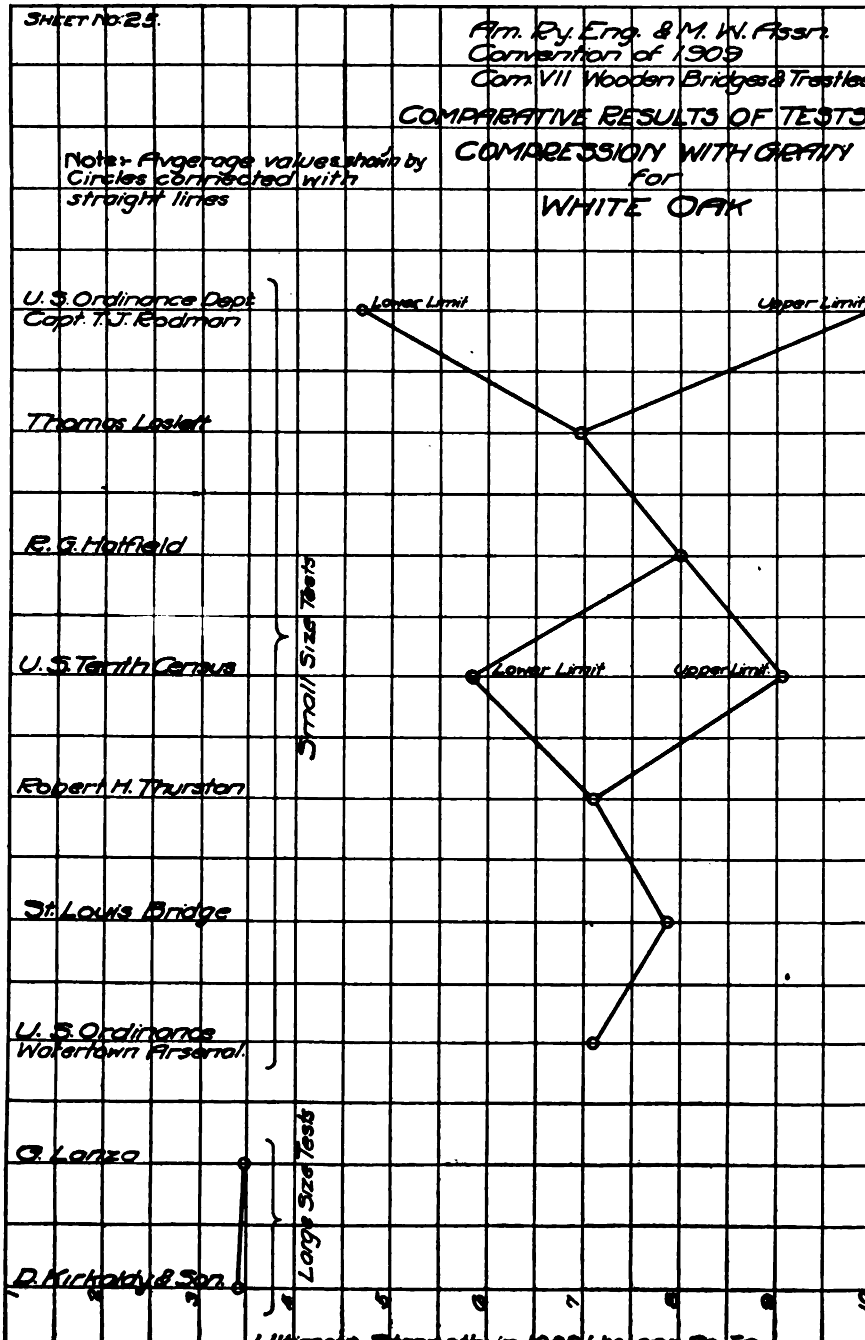

SHEET No 20
Am. Ry. Eng. & M.W. Assn.
Convention of 1909.
Com VII Wooden Bridges & Trestles
Note. Average Values shown by circles connected with Straight Lines.
COMPARATIVE RESULTS OF TESTS
MODULUS OF RUPTURE
FOR
WHITE OAK
U S Tenth Census
Lower Limit
Upper Limit
U.S. Ordinance Dept
Capt T.J. Rodman
Lower Limit
Upper Limit
Thos. Laslett
Robert H Thurston
Small Size Tests
G. Lanza
D. Kirkaldy & Son
Full Size Beams
Modulus of Rupture in Thousands of lbs per Sq In.
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

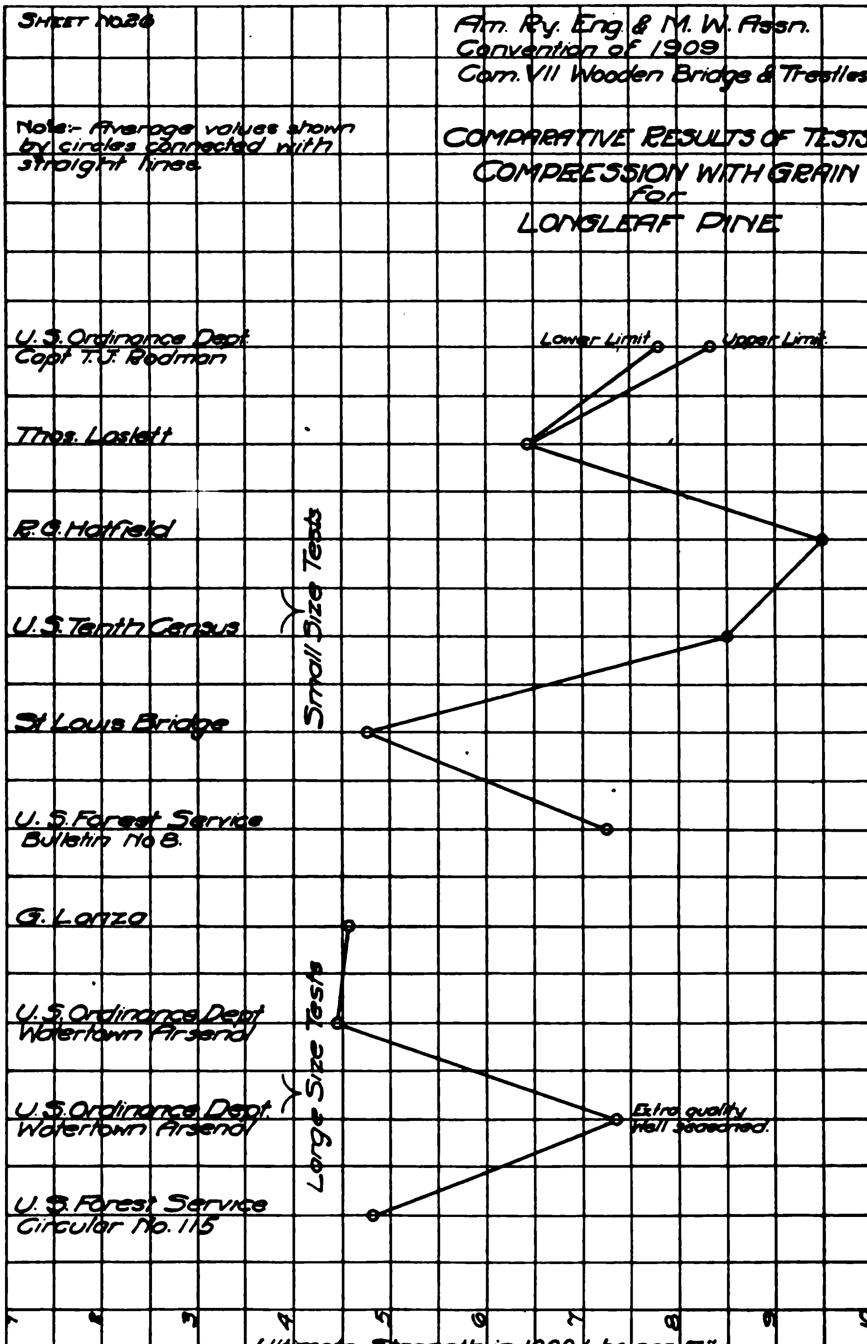

SHEET No 21
Am. Ry. Eng. & M.W. Assn.
Convention of 1909.
Com. VII Wooden Bridges & Trestles
Note: Average Values shown by Circles connected with Straight Lines.
COMPARATIVE RESULTS OF TESTS
MODULUS OF RUPTURE
FOR
LONGLEAF PINE
U.S. Ordinance Dept. Capt. T.J. Rodman
U.S. Tenth Census
Thos. Laslett
F.E. Kidder
R.G. Hatfield
Robert Thurston
U.S. Forest Service Clr. 115
G. Lanza
U.S. Forestry DIV. Bulletin No. 8
Small Size Tests
Full Size Beam
Lower Limit
Upper Limit
Lower Limit
Upper Limit
Modulus of Rupture in Thousands of lbs. per Sq. In.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

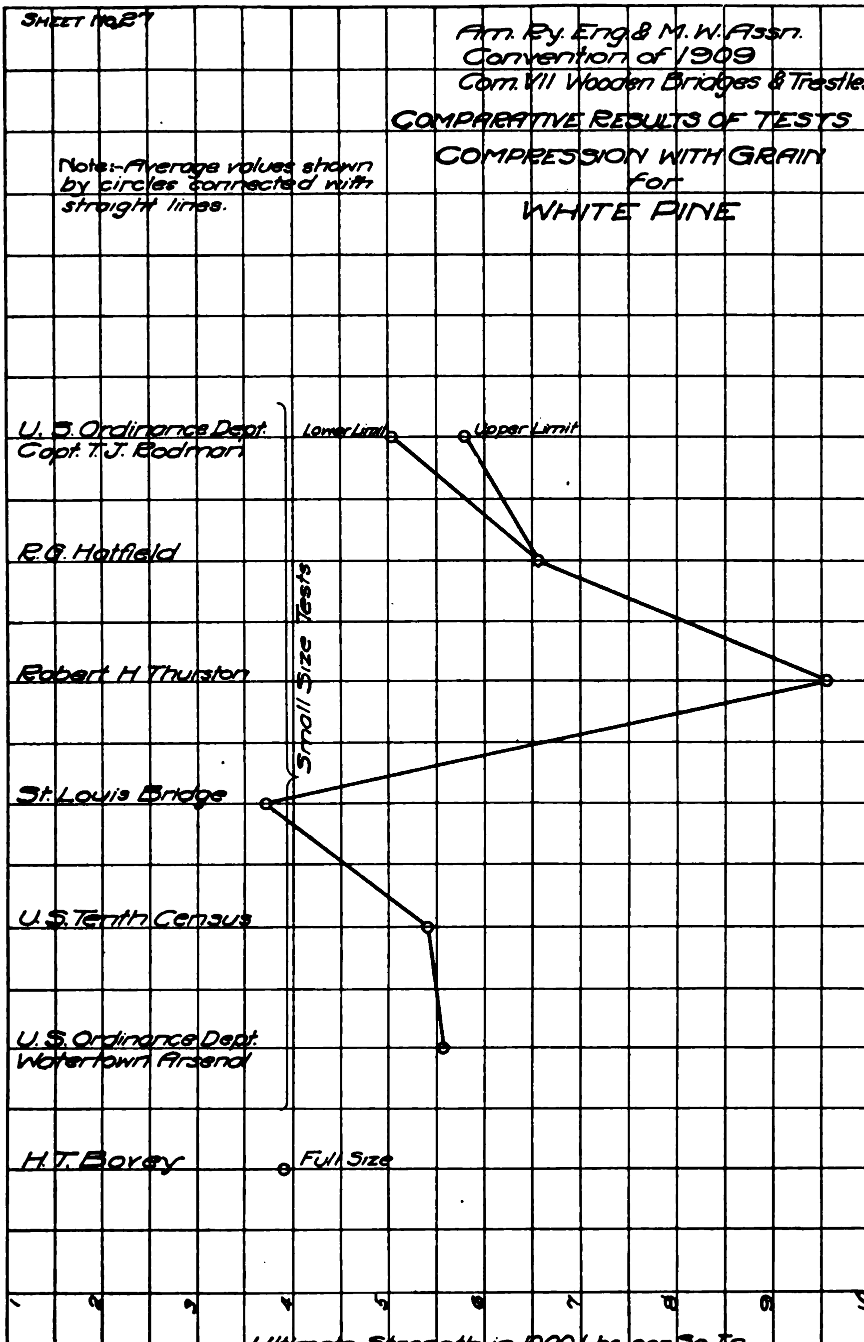

Sheet No. 28
Am. Ry. Eng. & M. W. Assn.
Convention of 1909.
Com. VII. Wooden Bridges & Trestles
Note: Average Values shown by Circles connected with Straight Lines
Comparative Results of Tests
Modulus of Rupture
for
White Pine
Small Size Tests
Full Size Beams
U.S. Tenth Census
U.S. Ordinance Dept. Capt. T. J. Rodman
F. E. Kidder
R. G. Hatfield
H. T. Bovey
Onward Bates
G. Lanzo
W. H. Finley
G. Lanzo
W. H. Finley
Lower Limit
Upper Limit
Lower Limit
Upper Limit
Modulus of Rupture in Thousands of lbs. per Sq. In.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

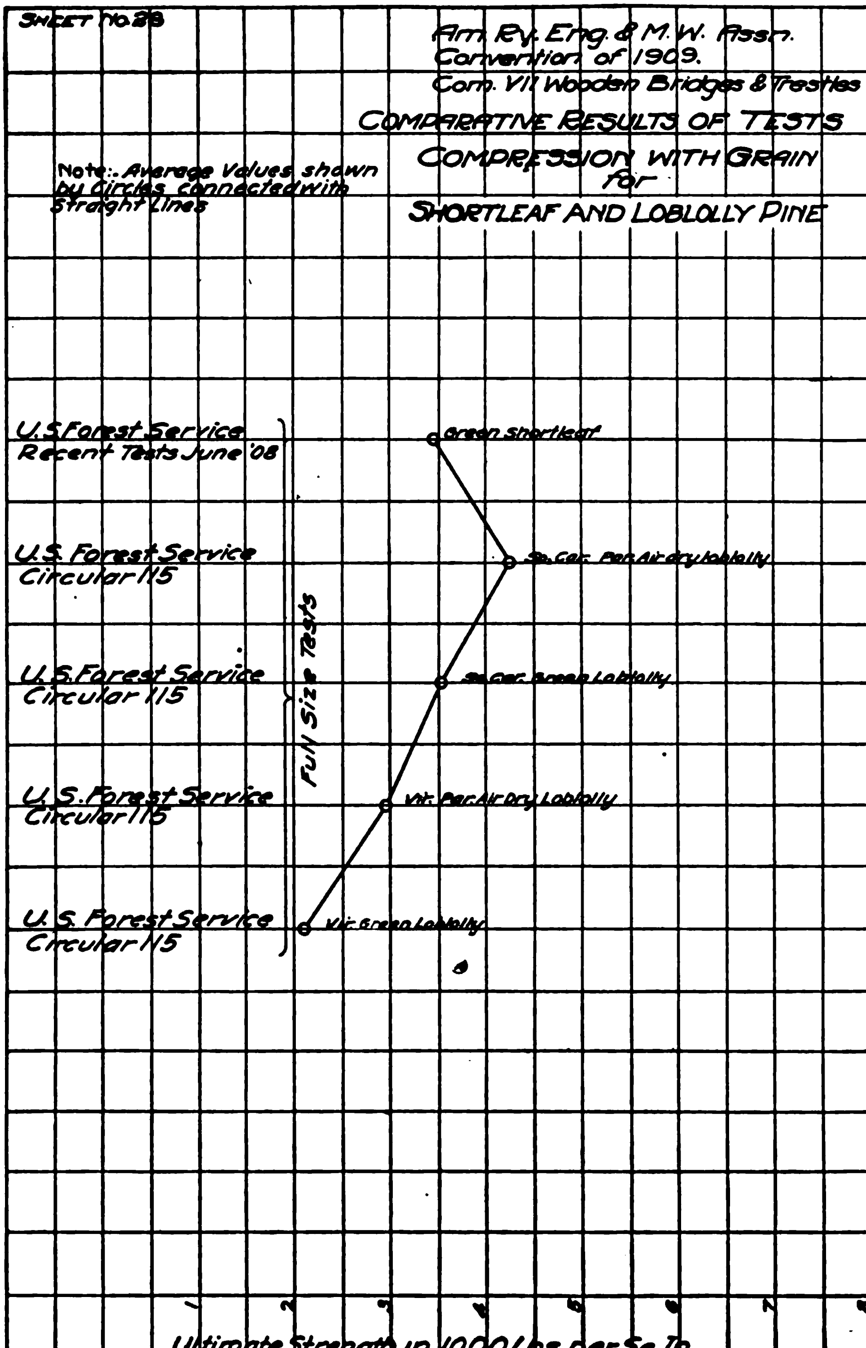

Sheet No. 23
Am. Ry. Eng. & M.W. Assn.
Convention of 1909.
Com. VII Wooden Bridges & Trestles
Note. Average Values shown by circles connected with Straight Lines.
Comparative Results Of Tests
Modulus of Rupture
for
Shortleaf and Loblolly Pine
U.S. Forest Service
U.S. Forest Service Cir. 115
U.S. Forest Service Cir. 115
U.S. Forest Service Cir. 115
U.S. Forest Service (Recent)
U.S. Forest Service (Recent)
Full Size Beams
Green Vir. Loblolly (Poor Quality)
Par. Air Dry Vir. loblolly.
Green So. Car. Loblolly
Par. Air Dry So. Car. loblolly
Short Leaf Pine
Loblolly
Modulus of Rupture in Thousands of lbs. per Sq. In.
1
2
3
4
5
6
7
8

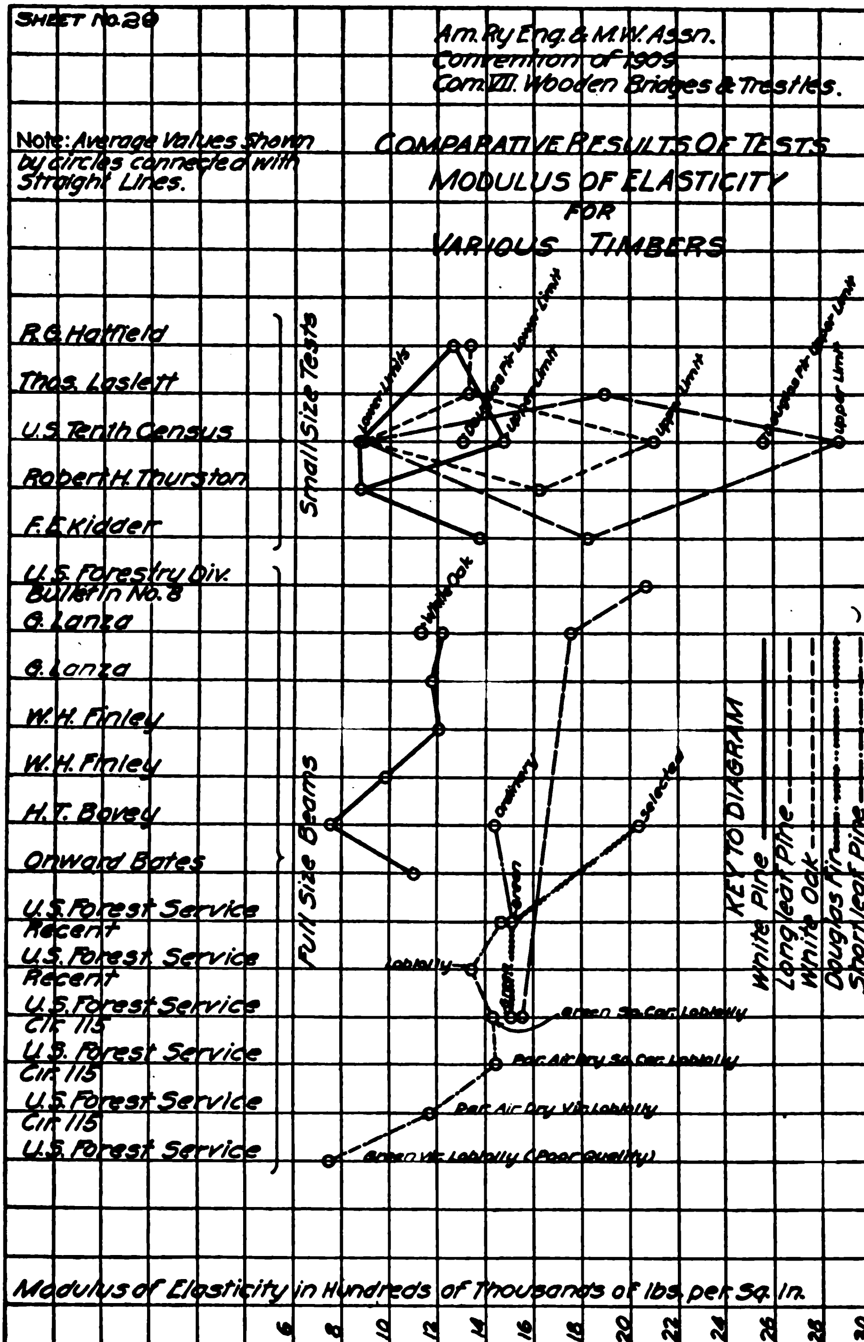

Sheet No. 24
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII- Wooden Bridges & Trestles
Note:- Average values shown by circles connected with straight lines
COMPARATIVE RESULTS OF TESTS
COMPRESSION WITH GRAIN
for
DOUGLAS FIR
U. S. Ordinance Dept. Capt. T. J. Rodman
White Fir
Red Fir
U. S. Tenth Census
Lower Limit
Upper Limit
W. B. Wright
Ore. & Cal. R. R.
John D. Isaacs S. P. R. R.
Small Size Tests
H. T. Bovey
U. S. Forest Service Circular No. 115
Par. Air Dry
U. S. Forest Service Circular No. 115
Green
U. S. Forest Service June 1908
Par. Air Dry
U. S. Forest Service June 1908
Green
Full Size Tests
1
2
3
4
5
6
7
8
9
10
Ultimate Strength in 1000 Lbs. per □"


SHEET No. 25.
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII Wooden Bridges & Trestles
COMPARATIVE RESULTS OF TESTS
COMPRESSION WITH GRAIN
for
WHITE OAK
Note:- Average values shown by Circles connected with straight lines
U. S. Ordinance Dept. Capt. T. J. Rodman
Lower Limit
Upper Limit
Thomas Laslett
R. G. Hatfield
U. S. Tenth Census
Lower Limit
Upper Limit
Robert H. Thurston
St. Louis Bridge
U. S. Ordinance Watertown Arsenal.
Small Size Tests
G. Lanza
D. Kirkaldy & Son.
Large Size Tests
1
2
3
4
5
6
7
8
9
10
Ultimate Strength in 1000 Lbs. per Sq. In.


Sheet No. 26
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII Wooden Bridge & Trestles
Note:- Average values shown by circles connected with straight lines.
COMPARATIVE RESULTS OF TESTS
COMPRESSION WITH GRAIN
for
LONGLEAF PINE
U. S. Ordinance Dept. Capt. T. J. Rodman
Lower Limit
Upper Limit
Thos. Laslett
R. G. Hatfield
U. S. Tenth Census
Small Size Tests
St Louis Bridge
U. S. Forest Service Bulletin No 8.
G. Lanza
U. S. Ordinance Dept. Watertown Arsenal
Large Size Tests
U. S. Ordinance Dept. Watertown Arsenal
Extra quality Well seasoned.
U. S. Forest Service Circular No. 115
1
2
3
4
5
6
7
8
9
10
Ultimate Strength in 1000 Lbs. per □"


Sheet No. 27
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII Wooden Bridges & Trestles
COMPARATIVE RESULTS OF TESTS
COMPRESSION WITH GRAIN
for
WHITE PINE
Note:- Average values shown by circles connected with straight lines.
U. S. Ordinance Dept.
Capt. T. J. Rodman
Lower Limit
Upper Limit
R. G. Hatfield
Robert H Thurston
Small Size Tests
St. Louis Bridge
U. S. Tenth Census
U. S. Ordinance Dept.
Watertown Arsenal
H. T. Bovey
Full Size
1
2
3
4
5
6
7
8
9
10
Ultimate Strength in 1000 Lbs. per Sq. In.


Sheet No. 28
Am. Ry. Eng. & M. W. Assn.
Convention of 1909.
Com. VII Wooden Bridges & Trestles
COMPARATIVE RESULTS OF TESTS
COMPRESSION WITH GRAIN
for
SHORTLEAF AND LOBLOLLY PINE
Note:- Average Values shown by Circles connected with Straight Lines
U.S. Forest Service Recent Tests June '08
Green Shortleaf
U.S. Forest Service Circular 115
So. Car. Per. Air dry Loblolly
U.S. Forest Service Circular 115
So. Car. Green Loblolly
U.S. Forest Service Circular 115
Vir. Per. Air Dry Loblolly
U.S. Forest Service Circular 115
Vir. Green Loblolly
Full Size Tests
1
2
3
4
5
6
7
8
Ultimate Strength in 1000 Lbs. per Sq. In.


SHEET No. 29
Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII. Wooden Bridges & Trestles.
Note: Average Values shown by circles connected with Straight Lines.
COMPARATIVE RESULTS OF TESTS
MODULUS OF ELASTICITY
FOR
VARIOUS TIMBERS
R. G. Hatfield
Thos. Laslett
U. S. Tenth Census
Robert H. Thurston
F. E. Kidder
U. S. Forestry Div. Bulletin No. 8
G. Lanza
G. Lanza
W. H. Finley
W. H. Finley
H. T. Bovey
Onward Bates
U. S. Forest Service Recent
U. S. Forest Service Recent
U. S. Forest Service Cir. 115
U. S. Forest Service Cir. 115
U. S. Forest Service Cir. 115
U. S. Forest Service
Small Size Tests
Full Size Beams
Lower Limits
Upper Limit
White Oak
Ordinary
Selected
Loblolly
Green Sq. Cor. Loblolly
Per. Air Dry Sq. Cor. Loblolly
Per. Air Dry Vir. Loblolly
Green Vir. Loblolly (Poor Quality)
KEY TO DIAGRAM
White Pine
Longleaf Pine
White Oak
Douglas Fir
Shortleaf Pine
Modulus of Elasticity in Hundreds of Thousands of lbs. per Sq. In.
6
8
10
12
14
16
18
20
22
24
26
28
30

SHEET No. 30.

Am. Ry. Eng. & M. W. Assn.
Convention of 1909
Com. VII. Wooden Bridges and Trestles

UNIT STRESSES FOR STRUCTURAL TIMBER EXPRESSED IN POUNDS PER SQUARE INCH

RECOMMENDED BY THE COMMITTEE ON WOODEN BRIDGES AND TRESTLES

Kind of Timber	BENDING			SHEARING				COMPRESSION						Ratio of Length of Stringer to Depth
	Extreme Fiber Stress		Modulus of Elasticity	Parallel to Grain		Longitudinal Shear in Beams		Perpendicular to Grain		Parallel to Grain		For Columns under 15 Diams.	Formulas for Safe Stress in Long Columns over 15 Diams.	
	Average Ultimate	Safe Stress	Average	Average Ultimate	Safe Stress	Average Ultimate	Safe Stress	Elastic Limit	Safe Stress	Average Ultimate	Safe Stress	Safe Stress		
Douglas Fir	6100	1200	1,510,000	690	170	270	110	630	310	3600	1200	900	$1200(1-\frac{L}{60D})$	10
Longleaf Pine	6500	1300	1,610,000	720	180	300	120	520	260	3800	1300	980	$1300(1-\frac{L}{60D})$	10
Shortleaf Pine	5600	1100	1,480,000	710	170	330	130	340	170	3400	1100	830	$1100(1-\frac{L}{60D})$	10
White Pine	4400	900	1,130,000	400	100	180	70	290	150	3000	1000	750	$1000(1-\frac{L}{60D})$	10
Spruce	4800	1000	1,310,000	600	150	170	70	370	180	3200	1100	830	$1100(1-\frac{L}{60D})$	—
Norway Pine	4200	800	1,190,000	590	130	250	100	—	150	2600*	800	600	$800(1-\frac{L}{60D})$	—
Tamarack	4600	900	1,220,000	670	170	260	100	—	220	3200*	1000	750	$1000(1-\frac{L}{60D})$	—
Western Hemlock	5800	1100	1,480,000	630	160	270*	100	440	220	3500	1200	900	$1200(1-\frac{L}{60D})$	—
Redwood	5000	900	800,000	300	80	—	—	400	150	3300	900	680	$900(1-\frac{L}{60D})$	—
Bald Cypress	4800	900	1,150,000	500	120	—	—	340	170	3900	1100	830	$1100(1-\frac{L}{60D})$	—
Red Cedar	4200	800	860,000	—	—	—	—	470	230	2800	900	680	$900(1-\frac{L}{60D})$	—
White Oak	5700	1100	1,150,000	840	210	270	110	920	450	3500	1300	980	$1300(1-\frac{L}{60D})$	18

Note:— These unit stresses are for a green condition of timber and are to be used without increasing the live load stresses for impact. *Partially air-dry.

L = length in inches.
D = least side in inches.

Amend headings in Sheet No. 30 to read "Working Stresses," instead of "Safe Stresses."

Add footnote, as follows: "Note.—The working unit stresses given in this table are intended for railroad bridges and trestles. For highway bridges and trestles the unit stresses may be increased twenty-five (25) per cent. For buildings and similar structures in which the timber is protected from the weather and practically free from impact, the unit stresses may be increased fifty (50) per cent. To compute the deflection of a beam under long-continued loading instead of that when the load is first applied, only fifty (50) per cent. of the corresponding modulus of elasticity given in the table is to be employed."

Appendix C.

PILES AND PILE DRIVING.

DEFINITIONS.

1. PILE.—A member usually driven or jetted into the ground and deriving its support from the underlying strata, and by the friction of the ground on its surface.

The usual functions of a pile are: (a) To carry a superimposed load; (b) To compact the surrounding ground; (c) To form a wall to exclude water and soft material, or to resist the lateral pressure of adjacent ground.

2. HEAD OF PILE.—The upper end of a pile.
3. FOOT OF PILE.—The lower end of a pile.
4. BUTT OF PILE.—The larger end of a pile.
5. TIP OF PILE.—The smaller end of a pile.
6. BEARING PILE.—One used to carry a superimposed load.
7. SCREW PILE.—One having a broad-bladed screw attached to its foot to provide a larger bearing area.
8. DISC PILE.—One having a disc attached to its foot to provide a larger bearing area.
9. SPUR PILE.—One driven at an inclination to resist the resultant of vertical and horizontal forces.
10. SHEET PILES.—Piles driven in close contact in order to provide a tight wall, to prevent leakage of water and soft materials, or driven to resist the lateral pressure of adjacent ground.
11. PILE DRIVER.—A machine for driving piles.
12. HAMMER.—A weight used to deliver blows to a pile to secure its penetration.
13. DROP HAMMER.—One which is raised by means of a rope and then allowed to drop.
14. STEAM HAMMER.—One which is automatically raised and dropped a comparatively short distance by the action of a steam cylinder and piston supported in a frame which follows the pile.
15. LEADS OR LEADERS.—The upright parallel members of a pile driver which support the sheaves used to hoist the hammer and piles, and which guide the hammer in its movement.
16. CAP, HOOD, BONNET.—A metal block used to protect the head of a pile and to hold it in the leads during driving.
17. RING.—A metal hoop used to bind the head of a pile during driving.
18. SHOE.—A metal protection for the point or foot of a pile.
19. FOLLOWER.—A member interposed between the hammer and a pile to transmit the blows to the latter when below the foot of the leads.

HISTORICAL.

Piles, or posts driven partly into the ground by blows of a hammer, are prehistoric in origin, and even the presumably later development of what are now termed "foundation" and "sheet piles" is too ancient to be a matter of record.

The primitive pile driver was a large maul or beetle wielded by one or more men, the effectiveness of which was limited, since the weight and drop depended upon the reach and strength of the human arm.

A heavier hammer raised by a pulley or roller supported at some distance above the pile head must have been the first great improvement in equipment. A number of men were thus able to use their strength, and by all letting go together the rope was drawn back by the descending hammer.

The insertion of a releasing hook in the connection of the line to the hammer and winding spools or crabs permitted the use of heavier hammers, the more effective use of man's strength and the use of horses.

The greatest impetus to the art was the introduction of the steam engine, which was probably first used (*) by John Rennie, 1801, 1802, for driving the piles of the cofferdam of the Bell Dock entrance to the London Docks. The engine employed was of 8 H. P. and was constructed by Messrs. Boulton & Watt. From this time on considerable attention was devoted to improvements in apparatus and new devices were employed more rapidly.

In 1834 Alexander Mitchell, the inventor of the screw mooring, having made some experiments with screw piles, proposed their use for a lighthouse at the entrance to the River Avon. His suggestions and plans were not carried out, and it was not until 1838 that they were used on the Maplin Sand Lighthouse. These piles were of wrought iron, 5 in. in diameter and 26 ft. long, with a 4-ft. cast-iron screw of one and one-quarter revolutions, keyed on near the end. The projecting end of the pile was provided with a screw point, and the piles were screwed 16 feet into the sand by handpower applied at a capstan head on a raft above.

The steam hammer, patented in France by Francois Bourdon in 1841, and in England by James Nasmyth in 1842, was first used on a pile driver about 1845. This apparatus attained immediate approval and thereafter was in quite general use in England on works of magnitude.

Labelye, in building the Westminster bridge in 1738, used an apparatus for cutting off piles under water. This was a wooden frame containing a cross-cut saw and was moved backward and forward by men standing on the platform above. A much more complicated machine, invented by De Cessart in 1756, could be operated with great precision and was applicable to a greater depth of water.

*The water jet as an aid to Engineering Construction, by L. Y. Schermerhorn, 1880.

The earliest authenticated (*) use of the water jet in sinking piles appears to have been introduced on the construction of a wharf at Decrows Point, Matagorda Bay, Texas, in 1852, and to have arisen from a suggestion made by Lieut. Geo. B. McClellan, Corps of Engineers, U. S. A. The water was pumped by an ordinary hand pump through a rubber hose with a gas pipe nozzle, the nozzle being placed close to the point of the pile.

In 1854 the foundation piles for the Pungateague Light, Chesapeake Bay, were driven by the aid of a water jet. These piles were hollow cast-iron pipes with flaring bases, and the water from a hand force pump was carried through a one-inch iron pipe inside of the pile.

Unless the above piles, with their flaring or bell-mouthed ends, are considered as a modified disc pile, the earliest use of the disc type sunk by jetting seems to have been adopted by James Brunlees in 1856, on the foundations of the Leven Viaduct, Morecambe Bay, England. Hollow cast-iron pipes were used, 10 in. in external diameter, bolted through outside flanges and having the base of the pile closed by a disc 2½ ft. in diameter. Ribs or cutters were formed on the bottom of the disc and a 3-in. hole provided for the water jet. Water was forced through a 2-in. iron pipe, passing down inside the pile, from a pump driven by a donkey engine, and a rotary motion was given to the pile to bring the cutters into play.

The first metal sheet piles were probably those used by Mathews in England, about 1822, and in that year the first patent was granted to Ewart for a cast-iron sheet pile of the ball and socket type. Subsequently other types were made of cast-iron, but owing to the character of the material no very extended application occurred until, with the more widespread use of steel, various inventors turned their attention to the subject.

The first rolled section of sheet piling patented in the United States was the ball and socket arrangement devised by Lewis Dodge in 1870. This was the forerunner of the "United States" type patented by S. K. Behrend in 1899, and of the many subsequent varieties of interlocking rolled sections. In 1893 August Simon of Gnadau, Germany, patented the first of the built-up sections, which in a modification now known as the "Jackson" type, was the first steel sheet piling driven in this country (Randolph Street Bridge, Chicago, in 1901). Further modifications of the built-up construction followed, i. e., the interlocking channel, "Friestedt" type, in 1902, the beam clip "Friestedt" type in 1903, and the succeeding modifications of various inventors.

SHEET PILING.

In the accompanying cuts, Figs. 1 and 2, are illustrated the various types of wooden sheet piling, and also the basic types of steel sheet

*G. Rennie, discussion of James Milne's paper, Description of Piling Machine Used at Montrose Harbor Works.—Proc. Inst. C. E., Vol. 52 (1844).

piling, together with those in most general use. A surprisingly large number of patents have been taken out for steel sheet piles, some of which are merely protecting patents and many of which are not on the market. Some types are not commercially practicable, owing to difficulties in manufacture, while others have not been brought forward in competition with more established makes. It is not intended at the present time to consider the question of desirable sections, and the sections shown are therefore submitted as fairly representing the development of the art.

REPLIES TO CIRCULAR LETTERS.

Circular letters were sent to the members of the Association and to a large number of outside engineers and contractors, and the following replies, giving the views of 47 railroad engineers (representing 37 roads) and 14 other engineers and contractors, were received:

Give the weight of hammer and height of drop and whether you recommend steam or drop hammer for various combinations of the following conditions: (a) Water Driver, (b) Land Driver, (c) Track Driver, (d) Soft Driving, (e) Medium Driving, (f) Hard Driving, (g) Foundation Piling, (h) Trestle Piling, (i) Sheet Piling, (j) Timber Piling, (k) Concrete Piling.

Kind of Hammer.	Weight of Hammer.	Water Driver. Character of Driving.				Land Driver. Character of Driving.				Track Driver. Character of Driving.				Remarks.
		Soft.	Med.	Hard	Not Given	Soft.	Med.	Hard	Not Given	Soft.	Med.	Hard	Not Given	
Drop	6,000				1									The allowable heights of drop were generally stated as being varied to suit local conditions.
Drop	5,000-4,000	1	1	1	2			1					1	
Drop	4,500				1									
Drop	4,500-3,200			1										
Drop	3,500				2				2				3	
Drop	3,500-3,000		1	1		1				1				
Drop	3,200				1				2				2	
Drop	3,200-2,800												1	
Drop	3,000	2	1	2	3	2	4	5	2	2	4	3	5	
Drop	3,200-2,200								1					
Drop	3,000-2,500	1	1	1	1				1				1	
Drop	3,000-2,200									1	1	1		
Drop	3,000-2,000	1	1	1		1	1	1	1	1	1	1	1	
Drop	2,800	1	1	1		1	2	2		1	2	2		
Drop	2,700												1	
Drop	2,600								1					
Drop	2,500	1	1	1	1	4	4	3	3	3	3	3	1	
Drop	2,500-2,200								1					
Drop	2,400												1	
Drop	2,500-2,000					2	2	1						
Drop	2,200												1	
Drop	2,000					3	2		5				2	
Drop	2,000-1,600								1					
Drop	2,000-1,500					1								
Drop	1,800								1					
Steam		1	3	3	7	2	5	8	6		2	2	8	
Steam	No. 2 Vulcan	1	2	1			2	2			1	1		
Steam	No. 1 Vulcan				2									

WOODEN SHEET PILING

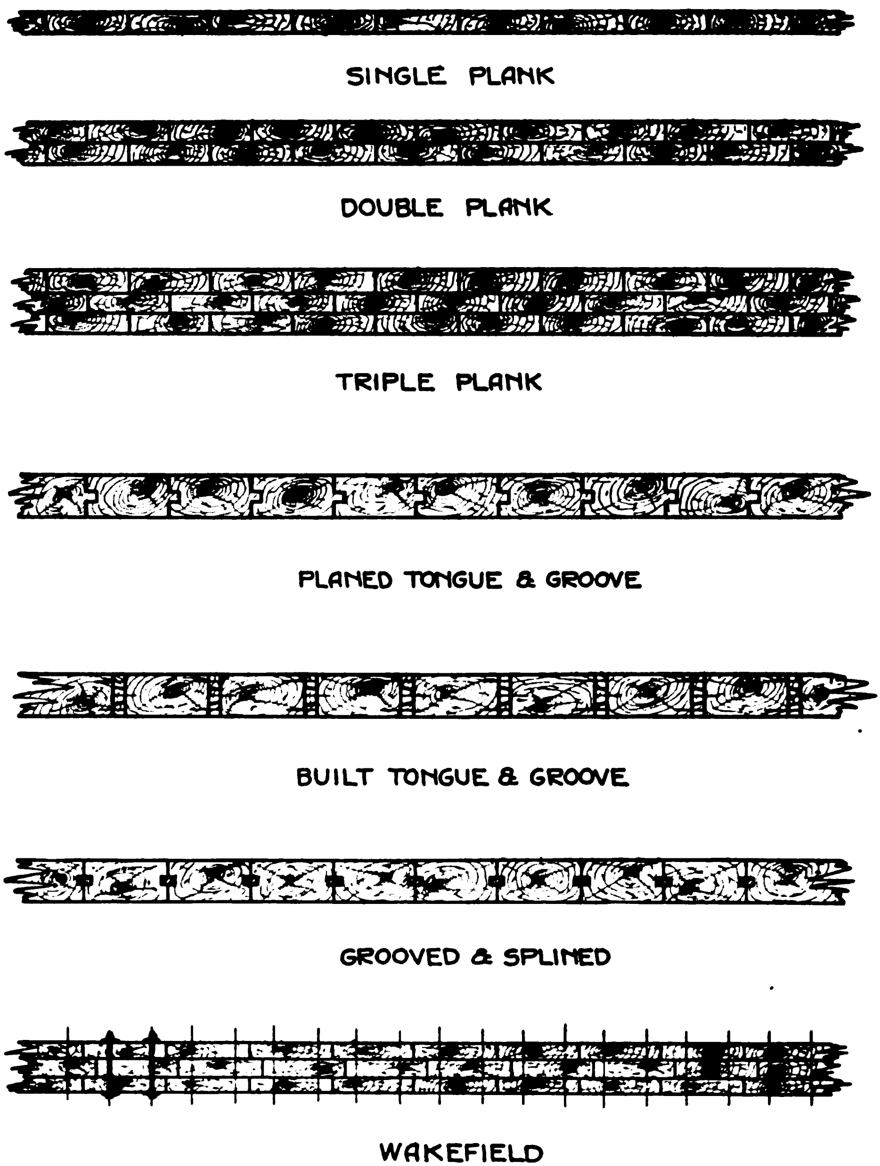


FIG. 1. PRINCIPAL TYPES OF WOODEN SHEET PILING.

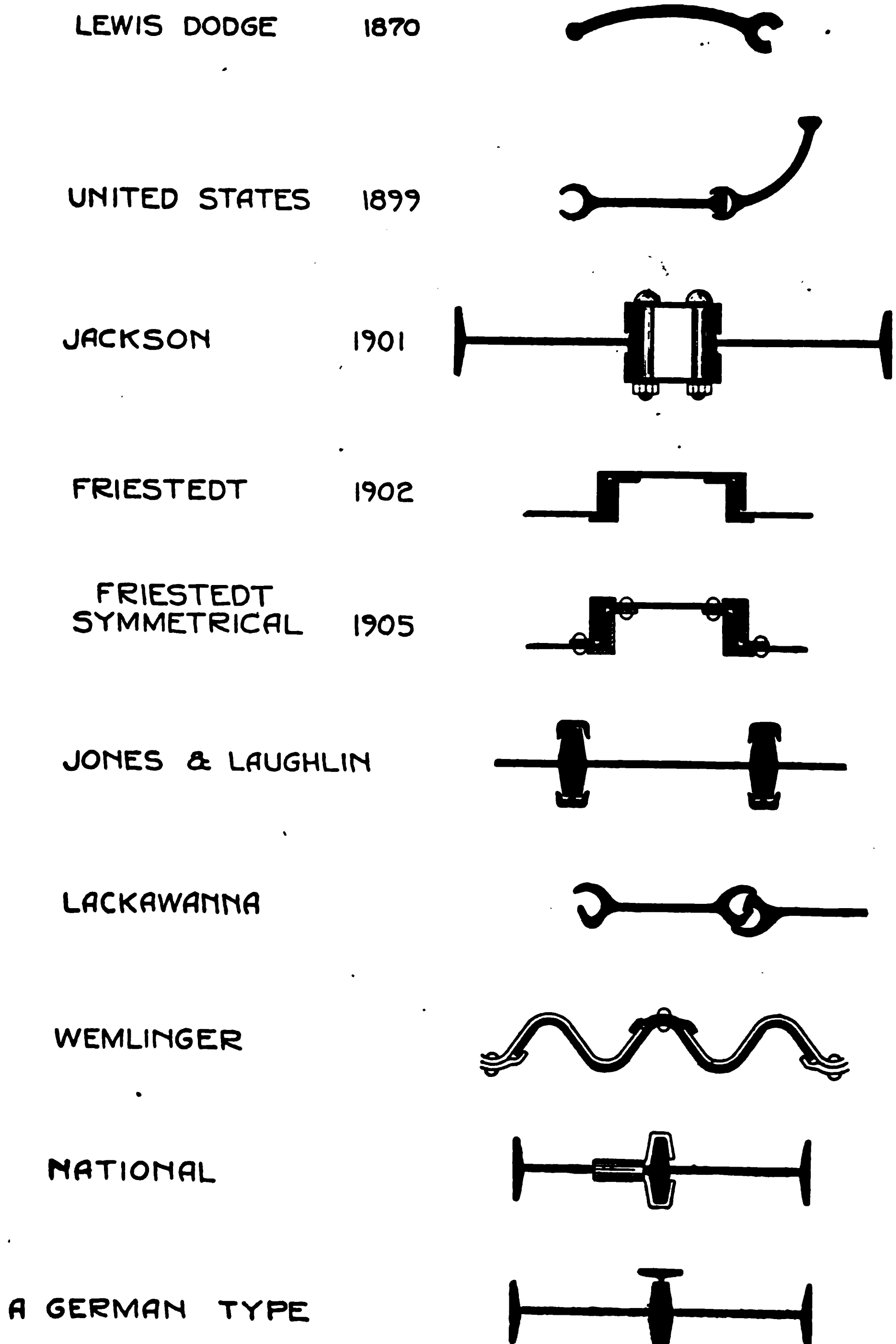


FIG. 2. PRINCIPAL TYPES OF STEEL SHEET PILING

As a railroad tool for miscellaneous work, do you prefer a drop or a steam hammer?

Steam hammer	9
Drop hammer	43
Steam hammer for track driver, drop hammer for land driver	1
Steam hammer for light work, drop hammer for heavy work	1
Steam hammer for heavy work, drop hammer for light work	1
Steam hammer where investment is warranted	1
No experience with, but approve theoretically	1
Total replies	57

Committee VII of the Association of Railway Superintendents of Bridges and Buildings in 1904 reported in favor of steam hammers for all kinds of pile driving, although their investigation showed comparatively few steam hammers in use on railroad work.

In both of the above investigations the preponderence of replies in favor of drop hammers is undoubtedly due in part to relative unfamiliarity with the actual use of steam hammers.

When do you recommend using rings?

When do you recommend using followers or caps?

Caps.—	
For general use	22
Except in soft driving	1
Rings.—	
For general use	5
Except in soft driving	12
In hard driving only	12
Total replies	52
Follower.—	
If necessary to drive below bottom of leads	18
To drive below ground surface	4
To reduce the amount of cut-off of valuable timber (creosoted)	5
Undesirable, avoid if possible	6
Total replies	33

When do you recommend using shoes?

In one or more of the following: Boulders, rip rap, coarse gravel, shale, slate, hard pan, buried timber, very hard clay	40
In cemented material only	1
To obtain a toe hold in rock, etc	8
Are of little value	4
Never	5
Total replies	58

Have you ever used a water jet? If so, under what conditions?

In sand, quicksand, gravel, etc.	40
To loosen piles which are being pulled	3
Have never used a water jet	14
Unsatisfactory in clay	3
Do not approve of use, cannot estimate safe load	1
Total replies	61

Have you driven "butt down"? If so, under what conditions?

In sand or loam, using a water jet	2
In soft driving	1
In sand on account of the pulling action of ice	1
In rock overlaid with mud	1
When splicing is necessary	1
For ferry slips	1
When butts were too large to enter leads	1
For tests only	1
When piles were very long and also when rock was close to the surface	1
In quicksand and also for false work	1
Have never driven "butt down"	41
Total replies	52

OVERDRIVING PILES.

The most prevalent bad practice in pile driving is overdriving, i. e., injuring the material of a pile by too violent or too continued hammering. When such injury occurs above ground, in the form of brooming or splitting, and can be prevented by the use of rings or caps, it is not regarded as an indication of overdriving. The use of such protective appliances as rings, caps, or shoes is a legitimate means for securing the necessary penetration of softwood timber and of even hardwood timber in difficult ground. When, however, the resulting injury occurs below the surface of the ground, and therefore in that portion of the pile which will be a part of the finished structure, the pile may be said to be overdriven. Injuries of this nature may consist of a slight brooming of the foot of the pile and so be negligible, or they may be of sufficient importance to imperil the stability of the structure.

Several types of failures are illustrated in Figs. 3, 4 and 5. The piles shown in Fig. 3 were almost shredded into their component fibers for considerable lengths. One of the piles in Fig. 4 sheared longitudinally, allowing the broken ends to pass each other and resulting in a pile whose length was merely that of the upper portion. The other pile shown in this figure buckled locally, forming an elbow joint, and remained attached to the lower section. Fig. 5 shows the brooming of the point of a pile by continued driving in cemented gravel.

Fig. 3. Overdriven Piles from the Foundation of the Naval Engineering Building, Massachusetts Institute of Technology, Park Square, Boston, Mass.

It is frequently claimed by contractors and their foremen, and with apparent reason, that engineers specify conditions regarding penetration due to the last blows which are too severe. Pile driving can never be an exact science, and the "practical man" seems to have some reason for his poor opinion of a specification which applies with equal force to every known and unknown condition of the ground.

Unfortunately, it is sometimes difficult to distinguish between the action of an overdriven pile and that of a perfectly sound pile in certain ground.

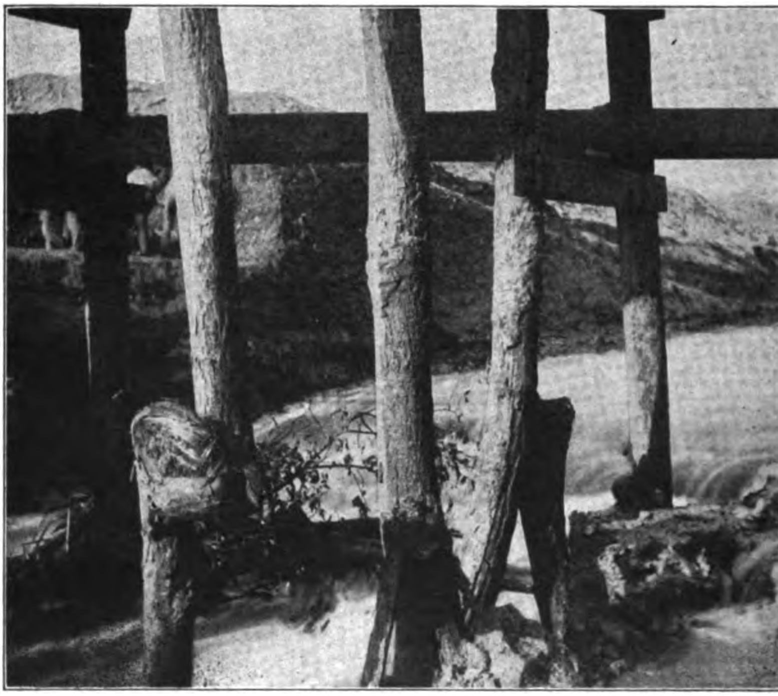


FIG. 4. OVERDRIVEN PILES IN TEMPORARY CONSTRUCTION FOR A HIGHWAY BRIDGE, NEAR DANVILLE, ILLINOIS.

Practice in the art and some investigation of the underlying conditions are perhaps the surest guides to success.

In general, overdriving may be due to one or more of the following causes: (1) The use of the word "refusal" in the specifications. (2) A belief in the prevalence of intermediate or floating hard strata. (3) The use of a light hammer and a long drop. (4) Attempting to force aside mythical small boulders. (5) An unnecessary effort to make the pile-driving record suit a formula which was not intended by the proposer thereof to apply to such cases.

It is usually claimed, in cases of overdriving, that no evidence of injury was shown during the driving. This claim is open to considerable doubt, and a more careful examination of the underlying strata should prevent many failures.

A pile passing through soft material and bringing up on rock cannot be driven into the rock. This condition indicates that another type of foundation may be needed. Pile foundations in ground hard enough to broom and split hardwood piles can often be otherwise designed with advantage.

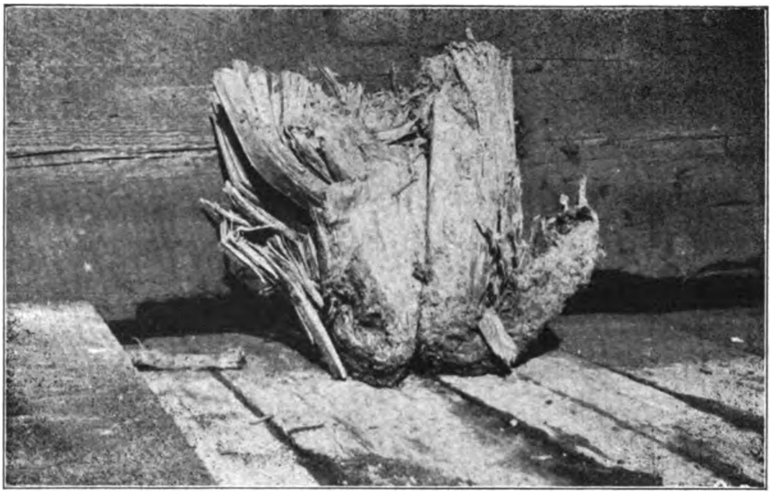


FIG. 5. POINT OF OVERDRIVEN PILE EXCAVATED DURING THE CONSTRUCTION OF THE FOUNDATION OF THE COLUMBIA RIVER BRIDGE AT VICTORIA, WASHINGTON.

Many kinds of ground, easily penetrated under continual driving, develop a skin friction in excess of the probable requirements. Short, quick blows of a heavy hammer produce the best results. A sudden change in the amount of penetration should be considered a suspicious occurrence. Finally, pile driving is a means, not an end, and a whole pile in almost any ground is better than pieces of a pile in good ground.

The piles referred to in Fig. 3 were spruce, 6-in. tip, 10-in. butt and 30 ft. long, driven with rings but without shoes. They were driven in made land, filled with gravel and boulders, by a 2,500-lb. drop hammer, with a maximum drop of 25 ft. and a final penetration of 1 in. due to a 15-ft. drop. It is reported that no evidence of injury appeared during the driving, failure being indicated by displacement or a suspicious appearance when partly exposed by the excavation.

The piles in Fig. 4 were oak, 8-in. tip and 20 to 25 ft. long. The

soil consisted of 5 or 6 ft. of loam, underlaid with glacial drift containing few large stones, followed by hard clay. A 2,000-lb. drop hammer was used and the piles driven to "refusal" with a total penetration of about 18 ft.

The ground into which the piles of Fig. 6 were driven consisted of a disintegrated strata of schist, containing considerable mica. At first glance this ground resembled sand, but actually contained so much fine material that under the action of water it appeared to melt. It was suggested that if water were extensively used around the piles they would drive easily into place. This suggestion was not acted upon and the driving was done with a 4,000-lb. hammer having a drop of from 20 to 25 ft. While the piles are said to have had a regular penetration toward the end of the driving of about 1 in. per blow, it was found upon excavating that they were in the condition indicated in the sketch.

The dotted portion of the piles is intended to indicate the direction taken and not the amount of divergence.

RECORD OF PILES IN FIG. 6.

Bent.	Pile No.	Length.		Depth of Failure Below Cut-off.		Diameter ot Point of Failure.	Direction of Failure.
		Ft.	In.	Ft.	In.	In.	
West...	4 R	29	0	14	9	10	Right.
	3 R	33	0	19	0	10.5	Back.
	2 R	32	0	25	0	15	Right.
	1 R	26	9	21	7	16	Right.
	1 L	27	0	......		..	Back.
	2 L	27	0	......		..	Broke.
	3 L	27	0	......		..	Straight.
	4 L	28	5	......		10	Right.
	5 L	27	0	21	5	10	Left.
East...	5 L	29	0	......		..	Right.
	4 L	29	0	......		..	Left.
	3 L	23	0	......		..	Right.
	2 L	25	5	......		..	Straight.
	1 L	26	5	......		..	Straight.
	1 R	25	3	......		..	Straight.
	2 R	27	4	......		..	Right.
	3 R	33	0	......		..	Straight.
	4 R	36	0	30	5	10	Left.
	5 R	28	0	18	7	10	Straight.

LIST OF QUESTIONS ON PILES AND PILE DRIVING.

Circular No. 104. Issued July, 1908.

1. Give weight of hammer and height of drop, and whether you recommend steam or drop hammer for various combinations of the following conditions: a, Water Driver; b, Land Driver; c, Track Driver; d, Soft Driving; e, Medium Driving; f, Hard Driving; g, Foundation Piling; h, Trestle Piling; i, Sheet Piling; j, Timber Piling; k, Concrete Piling. 2. As a railroad tool for miscellaneous work, do you prefer a drop or a steam hammer? 3. When do you recommend using rings? Please give dimensions. 4. When do you recommend using shoes? Please send detail. 5. When do you recommend using followers or

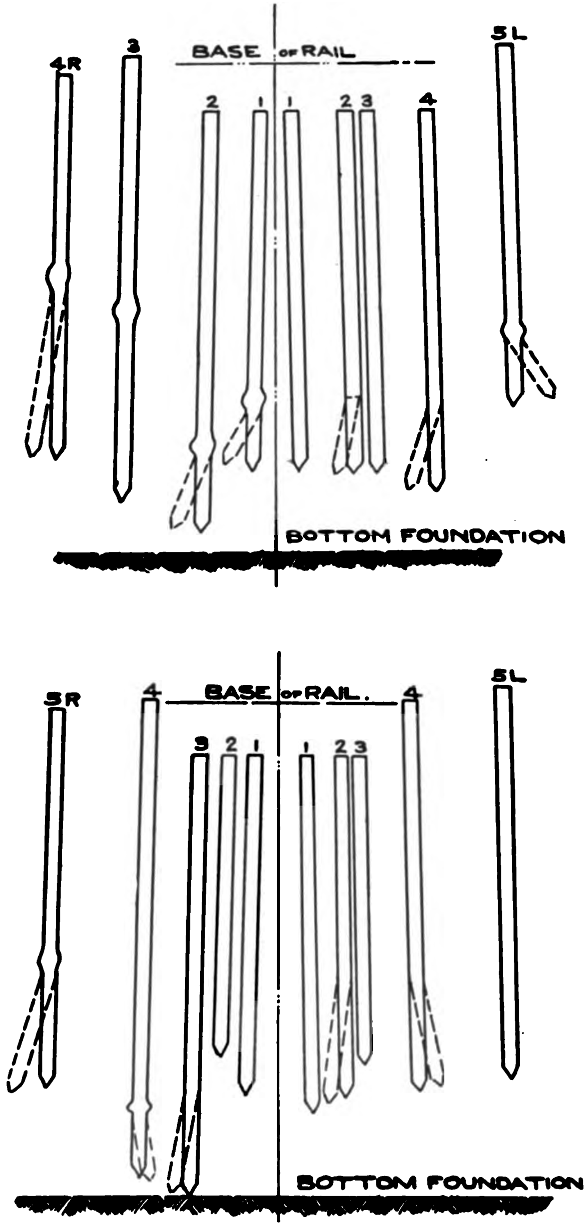


FIG. 6. OVERDRIVEN FALSE-WORK PILES, NEAR MARION, N. C.

caps? 6. Have you used a water-jet? If so, under what conditions? 7. Have you ever driven piles "butt down"? If so, under what conditions? 8. Can you furnish detailed information or photographs of over-driven piles? 9. Can you furnish records of pile driving in which the data are accurate and such as to aid in the study of the principles and methods involved?

Circular No. 105. Issued July, 1908.

1. Please describe (including weight of hammer, length of leads, kind and size of hoisting engine, men in crew) what you consider the best type of pile driver for: 1st, Water Driver; 2d, Land Driver; 3d, Track Driver; 4th, Land Driver supported on and driving trestle piles. 2. What do you consider the best types of steam hammer for various conditions? 3. What do you consider the best type of swinging leads, and at what batter can piles be driven thereby? 4. Please send sketch, photographs, or drawings of any or all of the best types referred to above. 5. What amount of coal and water should the types described use in a ten-hour day, and how many piles should be driven under: 1st, favorable conditions? 2d, average conditions? 6. What penetration, weight of hammer and drop do you consider proper for various conditions? 7. What are your views on the subject of splices? Please send sketch. 8. To what extent do you peel piles? 9. What is your experience as to creosoted piles standing hard driving?

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Appendix D.

ABSTRACT OF TALBOT'S TESTS OF FULL-SIZE STRINGERS.

These tests were made by the Engineering Experiment Station of the University of Illinois under the direction of Prof. A. N. Talbot. With a few exceptions the leading results are given only for longleaf yellow pine and Douglas fir. A considerable portion of the tests related to the strength of creosoted stringers of shortleaf and loblolly pine and of the relation between the strength of the treated and untreated timber.

One marked feature of the results consists in the analysis showing to what extent the strength is influenced by defects of various kinds. Another novel feature is that of the shearing tests of blocks cut from the stringers for the full width and at mid-depth as described in the note accompanying Table 3. The small sticks cut from the top and bottom of the stringers are also tested as beams, and the results are classified as illustrated in Table 5.

In general, knots and other defects seem to cause a larger number of failures on the lower or tension side than they cause failures by horizontal shear. With comparatively few exceptions the stringers which failed by horizontal shear developed a higher unit stress in shear than did those which failed on the tension side.

The data are not sufficient to determine how the kind of failure is influenced by the ratio of width to depth. In series A the horizontal shear failures include 75 per cent. of the 7 by 16, 33 per cent. of the 7 by 14, and 50 per cent. of the 7 by 12-in. stringers; while in series B this kind of failure includes 100 per cent. of the 7 by 16 and 83 per cent. of the 7 by 14-in. stringers. In series D, where the kind of timber is creosoted loblolly pine, the horizontal shear failures include 33 per cent. of the 7 by 16 and 17 per cent. of the 7 by 14-in. stringers.

In Table No. 4 the average of the percentages given is 75.7, but if the number of tests is taken into account the weighted mean is considerably higher. It must be remembered that the blocks were cut from the end which had the larger resistance to horizontal shear and did not fail. It will also be noticed that the lowest two percentages are not due to the low values of the horizontal shear but to the high shearing strength of the blocks. The averages of the horizontal shear in the 3 by 3-inch beams of the different series is from 10 to 84 per cent. greater than for the full size stringers, while the stress in the outer fiber is from 47 to 104 per cent. greater.

TABLE NO. 1.*

TESTS OF FULL-SIZE STRINGERS.

	Series A Partly Air-dry Longleaf Pine.	Series B Unseasoned Longleaf Pine.	Old Douglas Fir, 11 Years in Service.	New Douglas Fir.
Number of stringers tested	20	14	12	16
Percentage of horizontal shear failures	55	93	75	75
Percentage of tension failures	45	7	25	25
Percentage of all failures influenced by defects	25	14	42	43
Average of horizontal shear developed, lbs. per sq. in.	354	386	300	308
Average of stress in outer fiber, lbs. per sq. in.	5470	5430	4420	4520

*Series A had been sawn 12 months or more; Series B about 3 months.

TABLE NO. 2.

TESTS OF FULL-SIZE STRINGERS.

(The stresses are expressed in lbs. per sq. in.)

	Horizontal Shear Failures.			Tension Failures.		
	No. of Tests.	Average Horizontal Shear.	Average Stress in Outer Fiber.	No. of Tests.	Average Horizontal Shear.	Average Stress in Outer Fiber.
Series A. Partly Air-dry Longleaf Pine.						
All tests	11	374	5580	9	330	5335
Uninfluenced by defects	10	367	5550	6	380	6300
Influenced by defects	1	445	5895	3*	229	3070
Series B. Unseasoned Longleaf Pine.						
All tests	13	389	5440	1	344	5300
Uninfluenced by defects	12	402	5590	0	...	....
Influenced by defects	1	237	3620	1	344	5300
Old Douglas Fir. 11 Years in Service.						
All tests	9	311	4580	3	269	3960
Uninfluenced by defects	7	292	4280	0	...	....
Influenced by defects	2	376	5620	3	269	3960
New Douglas Fir.						
All tests	12	316	4630	4	279	4095
Uninfluenced by defects	9	312	4580	0	...	....
Influenced by defects	3	329	4770	4	279	4095

*These three sticks had been selected to show the effect of knots on the strength of the stick.

TABLE NO. 3.

SHEAR PARALLEL TO THE GRAIN.

Blocks 8 or 10 in. deep and about 12 in. long and of the full width of the stringer were cut from an end of the stringer which did not fail. The axis of the block coincided with the middle of the depth of the stringer. These blocks were tested in shear along the grain, and the results involve the effect of the presence of season checks and knots. The results given include all tests, no distinction being here made

between pieces from stringers failing in horizontal shear, tension or compression. (The shears are expressed in lbs. per sq. in.)

	Series A.		Series B.		Old Fir.		New Fir.	
	No. of Tests.	Average Shear.	No. of Tests.	Average Shear.	No. of Tests.	Average Shear.	No. of Tests.	Average Shear.
All tests	33	466	28	393	26	464	20	308
Uninfluenced by defects	16	493	15	428	13	509	6	381
Influenced by defects	17	442	13	353	13	420	14	277

TABLE No. 4.

RELATION OF HORIZONTAL SHEAR IN FULL-SIZE STRINGERS TO DIRECT SHEAR PARALLEL TO THE GRAIN IN BLOCKS CUT FROM THEIR UNINJURED ENDS.

Kind of Timber.	No. of Stringers.	Column (a)*	Column (b)*	Percentage Ratio.
Partly air-dry longleaf pine	11	374	466	80.2
Unseasoned longleaf pine	13	389	393	99.0
Untreated shortleaf pine	4	264	...	....
Untreated loblolly	3	379	764	49.6
Uncreosoted loblolly pine	5	314	403	78.0
Creosoted shortleaf pine (1)*	2	317	...	....
Creosoted shortleaf pine (2)	4	295	...	....
Creosoted loblolly pine (1)	1	368	665	55.4
Creosoted loblolly pine (2)	4	249	...	....
Creosoted loblolly pine	3	363	492	73.8
Old Douglas fir	9	311	464	67.1
New Douglas fir	12	316	308	102.5

*Column (a) gives the longitudinal shear developed in the full-size stringers which failed by longitudinal shear, their number being given in the first column, while column (b) gives the average of the results of shearing tests on all blocks cut from the stringers, including those which did not fail by horizontal shear. The stresses are expressed in pounds per square inch. The number of blocks tested is 259.

TABLE No. 5.

TESTS OF 3 BY 3-INCH BEAMS, SPAN 36 INCHES.

These sticks were cut from the top and bottom of the full-size stringers.

(All stresses are expressed in pounds per square inch.)

	Series A. Untreated Longleaf Pine.			Series B. Unseasoned Longleaf Pine.			Old Douglas Fir.			New Douglas Fir.		
	No. of Tests.	Hor. Shear.	Fiber Stress.	No. of Tests.	Hor. Shear.	Fiber Stress.	No. of Tests.	Hor. Shear.	Fiber Stress.	No. of Tests.	Hor. Shear.	Fiber Stress.
All tests	80	550	8820	51	517	8285	47	573	9000	46	462	7460
Horizontal shear failures	9	477	7700	0	...	....	8	487	7870	5	516	8295
Uninfluenced by defects	6	537	8570	0	...	....	3	621	9920	1	495	7875
Influenced by defects	3	357	5950	0	...	....	5	407	6640	3	530	8580
Tension failures	70	559	8950	22	522	8390	34	568	8810	33	439	7120
Uninfluenced by defects	55	594	9530	18	538	8650	26	599	9230	15	483	8190
Influenced by knots	9	431	6940	1	670	10900	4	442	7060	9	410	6590
Influenced by cross grain	5	418	6700	2	347	5525	3	504	8060	6	363	5050
Influenced by checks	0	...	....	0	...	....	1	454	7270	3	457	7510
Influenced by sapwood	1	396	6470	1	435	7060	0	...	....	0	...	....
Compression failures	1	625	10000	29	513	8200	5	743	12140	8	521	8390
Uninfluenced by defects	1	625	10000	21	540	8630	5	743	12140	8	521	8390
Influenced by cross grain	0	...	....	5	460	7390	0	...	....	0	...	....
Influenced by sapwood	0	...	....	3	412	6580	0	...	....	0	...	....

In series B, 4 tests were made with a span of 15 inches, giving an average horizontal shear of 1034, and an average fiber stress of 6990. One failed by horizontal shear, one by tension, and two by compression. One test was made for old Douglas fir with a span of 20 inches, which failed by horizontal shear, giving a horizontal shear of 992 and a fiber stress of 8700. One test was made for new Douglas fir with a span of 18 inches, which failed by horizontal shear along an annular ring, giving a horizontal shear of 750 and a fiber stress of 6000.

TESTS OF REDWOOD AT UNIVERSITY OF CALIFORNIA.

Timber purchased in the open market; origin unknown; partially seasoned; tested in 1901.

(All stresses are expressed in lbs. per sq. in.)

Flexure. Nominal size, 6 in. by 6 in., span 100 in.

Number of tests, 12.	Average.	Maximum.	Minimum.
Per cent. of moisture at test	58.7	96.5	26.9
Specific gravity of dry wood	0.398	0.548	0.279
Annual rings per inch	22.0	36.0	9.5
Fiber stress at yield point	5530	7800	4320
Modulus of rupture	6990	10400	5000
Modulus of elasticity	1222000	1622000	928000

Tension.

Number of tests, 69.			
Per cent. of moisture at test	15.6	25.0	11.4
Tensile strength at rupture	9470	15240	5540

Compression Parallel to Fiber.

Number of tests, 66.			
Per cent. of moisture at test	42.1	92.1	17.2
Crushing strength at rupture	4560	6890	3530

Compression Perpendicular to Fiber.

Number of tests, 47.			
Per cent. of moisture at test	40.4	97.5	16.6
Strength at compression of 3 per cent. of height	678	1236	394
Crushing strength, compression 15 per cent. of height	913	1677	567

Shear Parallel to Fiber.

Number of tests, 68.			
Per cent. of moisture at test	17.3	38.2	13.3
Shearing strength at rupture	422	934	229

MONTEREY REDWOOD. GREEN STICKS. TESTED IN 1900.

(All stresses are expressed in lbs. per sq. in.)

Flexure. Nominal size, 6 in. by 6 in., span 100 in.

Number of tests, 4.	Average.	Maximum.	Minimum.
Per cent. of moisture at test	182.9	193.5	173.0
Specific gravity of dry wood	0.329	0.341	0.318
Fiber stress at yield point	3688	4500	3250
Modulus of rupture	4438	5590	3830
Modulus of elasticity	616000	743000	521000

Tension.

Number of tests, 14.			
Tensile strength at rupture	4666	8490	3760

Compression Parallel to Fiber.

Number of tests, 37.			
Crushing strength at rupture	2982	3830	2100

Compression Perpendicular to Fiber.

Number of tests, 28.			
Strength at compression of 3 per cent. of height	653	817	516
Crushing strength, compression 15 per cent. of height	876	1163	612

Shear Parallel to Fiber.

Number of tests, 24.			
Shearing strength at rupture	263	364	172

DISCUSSION.

Prof. Henry S. Jacoby (Cornell University):—Mr. President, the report of the Committee on Wooden Bridges and Trestles is in Bulletin 107, and the conclusions are given on page 10. The specifications, which form the first part of the report, will be found on the following page. The Committee received instructions to hold a conference with the corresponding committee of the Yellow Pine Manufacturers' Association and the American Society for Testing Materials, and I have requested Mr. Bainbridge, who is the chairman of the subcommittee of conference, to make the statement concerning this part of our work.

Mr. F. H. Bainbridge (Chicago & Northwestern):—The matters to be decided on, on which there was a disagreement, were considered by Committee Q, of the American Society for Testing Materials, and the sub-committee of this Association. Committee Q allowed dead timber to be used. This was discussed at the meeting of the subcommittee Q and the sub-committee of this Association and the committee of the Yellow Pine Manufacturers' Association at the Chicago Beach Hotel, held last June. On this matter we agreed to give in, on the ground that in the present state of our knowledge that dead timber, meaning timber which had been burned over, was good if it was sound. The word "sound," of course, covers the timber that is decayed or worm-eaten. Committee Q had specifications regarding "wind," "wind" meaning a twist in the stick. At that meeting it was agreed to include the wind. Committee Q allowed sawing one-quarter-inch scantling size, and that was agreed to. Committee Q permitted loose knots except within four inches of the edges of the stringers. Our position forbidding any loose knots was agreed to by all. Committee Q permitted knots in corners of posts, which was agreed to. In respect to percentage of heart, the entire specification was changed at the request of the Yellow Pine Manufacturers' Association, and a specification adopted on the basis of the girth of the stringer. This was for the reason that in a long stringer, on one of the narrow faces, there might be a thin sliver of sap running out, to which there would be no particular objection.

Mr. L. C. Fritch (Illinois Central):—I suggest that these specifications be taken up clause by clause, in order that these different items can be discussed.

Mr. Bainbridge:—I wanted to follow through a general statement of the results of the conference. That is the important feature. It is not primarily the specifications which is before us, but it is the result of the conference. We are trying to come to an agreement.

Mr. L. C. Fritch:—My suggestion was merely to save time.

Mr. Bainbridge:—Of the other matters, there is not much of special importance, and we will omit reference thereto; but as to the further results, after these specifications had been agreed on and

the parties to the conference began to think it over, each one wanted to change something, so that we are still quite as far from an agreement as we were in the first place. But we have been getting close to the Yellow Pine Manufacturers' Association. The Committee had a meeting with Mr. Nelson, representing that Association, last night, and we disagreed in comparatively unimportant matters, in some respects, but the items of difference are these: In the first place, they object to our grading, and we wish to stick to it. We have No. 1 R. R., and No. 2 R. R. They want to call grade No. 1 heart, and grade No. 1. Then, they object to the terms "straight and true," true referring to a uniform cross-section, and straight to a straight axis in the stick. Now, we are willing to cut out the word "true" on the ground that standard sawing that you read here covers that close enough, but we wish to retain the word "straight." The other was as to "knots," in paragraphs 7, 8, 9, 13 and 14, in which our Committee was willing to meet them. There are some minor points in there, and beginning at paragraph 1, the Committee would ask that the word "trees" be eliminated, as that word was put in there because we originally specified live trees, and the matter was overlooked when the word "live" was cut out. Then there is an obvious omission in the specification that all parties have agreed to change. Paragraph 4 had in it, "all knots shall in no case exceed 4 inches in their largest diameter." That was in the specification for the second grade, but overlooked in the first grade. We add it to the first grade.

One member of the Association, who is very well informed in the matter, is of the opinion that the specifications for fir should be separated from the specifications for yellow pine. That has always been my own idea of the matter as well, and the Committee have all agreed to that.

It is the intention of the Committee to ask the approval of these specifications as submitted for yellow pine and withdraw the specifications as far as they refer to Oregon fir, and leave the specifications for Oregon fir to be gone into further in the following year.

Prof. Jacoby:—Perhaps it was not made sufficiently clear by Mr. Bainbridge that the form in which the specifications are printed in the Bulletin is practically the form which was agreed to by the Committee in conference last summer in Chicago. But, on account of the arguments, as stated by Mr. Bainbridge, certain changes will now be proposed which have been arranged at yesterday's conference. It will be understood that the first paragraph under No. 1 R. R. Grade will be considered with all reference to Douglas fir cut out entirely.

The President:—The chair extends the privileges of the floor to any representatives of the Forest Service who may be present.

The Secretary:—"Standard Specifications for Bridge and Trestle Timbers.—(To be applied to solid members and not to composite members.) General Requirements. 1. Except as noted, all timber shall

be cut from sound trees, true and straight, and sawed standard size; shall be square edged, close grained, solid and out of wind; free from defects such as injurious ring shakes and crooked grain, unsound or loose knots, knots in groups, decay, large pitch pockets, or other defects that will materially impair its strength."

Prof. Jacoby:—The Committee offers the following as a substitute for what has just been read: "Standard Specifications for Southern Yellow Pine Bridge and Trestle Timbers. (To be applied to single sticks and not to composite members.) 1. Except as noted, all timber shall be sound, sawed to standard size, square edged, and straight; shall be close grained and free from defects such as injurious ring shakes and cross grain; unsound or loose knots, knots in groups, decay, or other defects that will materially impair its strength."

(There being no objection, the substitute was adopted.)

The Secretary:—"Standard Size of Sawed Timber. 2. Rough timbers sawed to standard size means that they shall not be over one-fourth (¼) in. scant from the actual size specified. For instance, a 12 in. by 12 in. timber shall measure not less than 11¾ by 11¾ in.

"Standard Dressing of Sawed Timber. 3. Standard dressing means that not more than one-fourth (¼) in. shall be allowed for dressing each surface. For instance, a 12 in. by 12 in. timber, after being dressed on four sides, shall measure not less than 11½ by 11½ in.

"No. 1 R. R. Grade. Longleaf Yellow Pine and Douglas Fir. Stringers. 4. Longleaf pine shall show not less than eighty-five (85) per cent. heart on the girth anywhere in the length of the piece; provided, however, that if the maximum amount of sap is shown on either narrow face of the stringer, the average depth of sap shall not exceed one-half (½) in. Douglas fir shall show not less than ninety (90) per cent. heart as measured above. Knots greater than 1½ in. in diameter will not be permitted at any section within 4 in. of the edge of the piece."

Prof. Jacoby:—The sentence beginning with "Douglas fir" is to be omitted, and an addition to be made as follows: "But knots shall in no case exceed four (4) in. in their largest diameter."

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—As the Committee proposes to drop out of these specifications all reference to Douglas fir, I suggest that the words "longleaf pine" be omitted in the first line of section 4, and the words "Douglas fir" be omitted from the sub-heading immediately preceding section 4.

The Secretary:—"Caps and Sills. 5. Shall show not less than eighty-five (85) per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece; to be free from knots over two and one-half (2½) in. in diameter.

"Posts. 6. Shall show not less than seventy-five (75) per cent. heart on each of the four sides, measured across the sides anywhere in the length of the piece, and to be free from knots over two and one-half (2½) in. in diameter.

"Longitudinal Struts or Girts. 7. One face shall show all heart;

the other face and two sides shall show not less than eight-five (85) per cent. heart, measured across the face or sides anywhere in the length of the piece, and shall be free from knots one and one-half (1½) in. in diameter and over."

Prof. Jacoby:—The proposed change in this paragraph, as well as in several others that will follow, after the words "shall be free from" in next to the last line, consists in substituting "any large knots or other defects that will materially injure its strength."

Mr. L. C. Fritch:—The specifications would be a little more complete if the members were stated in the body of the specification, instead of as a marginal reference. The marginal reference does not make it complete. Take paragraph 5; it says, "shall not show less than 85 per cent.," etc.; if the paragraph started with the words "caps and sills" it would show definitely what the paragraph referred to.

Prof. Jacoby:—These marginal references could be placed at the beginning of the respective paragraphs. I think that would be advantageous.

The Secretary:—"Longitudinal X Braces, Sash Braces and Sway Braces. 8. Shall show four square edges and not less than eighty (80) per cent. heart on two faces, and shall be free from knots over one and one-half (1½) in. in diameter.

"Ties and Guard Rails. 9. Shall show one face all heart; the other face and two sides shall show not less than seventy-five (75) per cent. heart, measured across the face or side anywhere in the length of the piece; shall be free from knots over two and one-half (2½) in. in diameter, and where surfaced the remaining rough face shall show all heart."

Prof. Jacoby:—We propose the same change in these paragraphs as in No. 7.

Mr. Robert Ferriday (Cleveland, Cincinnati, Chicago & St. Louis). —The Big Four are revising their timber specifications, and desire to get in line with the Maintenance of Way specifications. The question came up, why in the smaller size sticks less heart was acceptable. The claim is generally made that it is very difficult to get a good portion of heart in large sticks. Here in a small stick less heart is accepted. What is the idea of the Committee in accepting less heart?

Mr. Bainbridge:—The claim of the manufacturers is that they have a certain portion of material for which they have no other means of disposition, and that leaves them with timber that they cannot use. If we carry our heart requirements through the whole list, they claim that will greatly increase the expense of all material furnished.

Mr. J. E. Snell (Delaware, Lackawanna & Western):—I ask why the greater percentage of sap allowance should not be taken care of in grade No. 2?

Mr. C. P. Howard (Lake Shore & Michigan Southern):—What

is the idea in cutting out these figures that give the size of the knots, and describing the objectionable knots as any knot that will impair the strength of the material? We have something here which is definite to go by, and it would seem the other way would leave it open to dispute.

Mr. Bainbridge:—The matter was contained in our original agreement with the Yellow Pine Manufacturers' Association. They claim there are certain positions in a stick in which almost any knot could be allowed. For instance, you could take the extreme end of a girt and plaster it with knots, and it would not do any harm. They felt it was a matter that could well be left to the inspector in cases of certain material. We have met them half-way, and do not specify the sizes of knots any more and leave the question to be decided according to the new definition.

The Secretary:—"No. 2 R. R. Grade, Longleaf and Shortleaf Yellow Pine, Douglas Fir and Western Hemlock.—Stringers. 10. Shall be square edged, except that it may have one (1) in. wane on one corner. Knots shall not exceed in their largest diameter one-fourth (¼) the width of the face of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

"Caps and Sills. 11. Shall be square edged, with the exception of one (1) in. wane on one corner, or one-half (½) in. wane on two corners. Knots shall not exceed in their largest diameter one-fourth (¼) of the width of the face of the stick in which they occur, and in no case shall exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

"Posts. 12. Shall be square edged, with the exception of one (1) in. wane on one corner, or one-half (½) in. wane on two corners. Knots must not exceed, in their largest diameter, one-fourth (¼) of the width of the face of the stick in which they occur, and shall in no case exceed four (4) in. Ring shakes shall not extend over one-eighth (⅛) of the length of the piece.

"Longitudinal Struts or Girts. 13. Shall be square edged and sound, and shall be free from knots one and one-half (1½) in. in diameter and over.

"Longitudinal X Braces, Sash Braces and Sway Braces. 14. Shall be square edged and sound, and shall be free from knots two and one-half (2½) in. in diameter and over."

Prof. Jacoby:—In paragraphs 13 and 14 we propose the same change as in paragraph 7.

Mr. J. B. Berry (Chicago, Rock Island & Pacific):—Does the Committee propose to make a specification for timber that is to be creosoted?

Mr. Bainbridge:—We thought that matter should be assigned to the committee looking after the matter of creosoting.

Mr. L. C. Fritch:—Does the Committee intend to leave Douglas fir and Western hemlock in the specifications for No. 2 R. R. Grade?

Mr. Berry:—I know that on the Illinois Central that question is pertinent; also on our own line. On the Illinois Central, if I understand rightly, they take the timber in the yard and sort out the timber not to be creosoted, which is all heart timber. The balance is not enough to furnish timber to be creosoted. We undertook to do the same thing on the Rock Island, and, strange to say, the heart timber was so much in excess of the specification that we were unable to properly treat it. We had to adopt a makeshift, so I believe it will be necessary to have a special specification for timber to be creosoted, as we do not get enough sap timber out of the ordinary run, if we use any quantity of creosoted timber.

Prof. Jacoby:—Answering the question of Mr. Fritch, it is proposed to eliminate the words "Douglas fir" and "Western hemlock" from the title of No. 2 R. R. Grade.

Mr. W. H. Courtenay (Louisville & Nashville):—How is the inspector to ascertain how far along the length of the stick the ring shakes extend?

Mr. J. C. Nelson (Seaboard Air Line):—It seems to me that these specifications are made up primarily for timber which is not to be treated, and should not that be made clear at the beginning of the specifications? I think we will need an entirely different set of requirements for timber that is to be creosoted, just as Mr. Berry has stated.

Mr. L. C. Fritch:—I move that conclusion 1 be adopted, as amended.

(Motion carried.)

Prof. Jacoby:—In connection with the discussion of these specifications, it has seemed desirable, in order to secure a more general agreement in regard to the use of terms for the future, that we should have a series of definitions to accompany the specifications, in addition to those which have been adopted heretofore, and the Committee desires to present these definitions for the information of the Association, and asks that they be printed in the Bulletin and come up in regular form next year.

Mr. W. C. Cushing (Pennsylvania Lines):—Should they not, instead of coming up in regular form for discussion on the floor, be discussed in writing after appearing in the Bulletin, and, if necessary, proposed changes to be voted on by letter-ballot? The Association made a ruling that it does not want to enter into a discussion of definitions on the floor of the house.

Prof. Jacoby:—I simply desired to make the statement that these definitions were in preparation and would be submitted for publication in the Bulletin.

I now move the adoption of conclusion 3: "That the revised specifications for timber piles be approved."

Mr. L. C. Fritch:—I suggest that the specifications be read paragraph by paragraph.

The Secretary:—"Specifications for Timber Piles—No. 1 R. R.

Grade.—1. This grade includes white, burr and post oak, longleaf pine, Douglas fir, tamrack, Eastern white and red cedar, Western cedar, redwood and cypress.

"2. Piles shall be cut from sound trees; shall be close grained and solid, free from defects, such as injurious ring shakes, large and unsound or loose knots, decay or other defects which may materially impair their strength or durability. In Eastern red or white cedar a small amount of heart rot at the butt, which does not materially injure the strength of the pile, will be allowed."

Mr. Nelson:—We should specify more clearly what is meant by cypress. There are a number of different kinds; some good and some no good. Is it the intention of the Committee to take out Douglas fir in piling and make separate specifications for that material for piling as well as for bridge timber?

Mr. Snell:—I notice the shortleaf yellow pine piles are omitted from the list. It is quite necessary in the East, for tidewater or meadow land construction, that we should purchase and use shortleaf yellow pine piles, which are very lasting when the cutoff is below mean tide or at an elevation where the piling will be always wet and where the water is foul to the extent that the teredo cannot live. In fact, we have to depend largely upon shortleaf yellow pine piles for construction of our piers.

Mr. Jos. O. Osgood (Central Railroad of New Jersey):—I notice that the specification for No. 1 R. R. Grade does not include chestnut, neither does it include spruce. Spruce is not a suitable timber, as I understand, for work away from the water, but it is used in Eastern waters for a first-class pile. It probably stands as well in docks in New York City as yellow pine, and at times is more expensive. Chestnut is used a great deal in the East and makes an excellent pile. It is durable as regards decay, and strong enough for all practical purposes.

Mr. Snell:—My experience in driving chestnut piles is, that where you have to strike a hard hammer blow for driving, the pile most invariably splits for a distance from the butt end, which impairs its strength by reducing the size of the vertical column it is supposed to form. However, where piling is driven in mud or silt, depending entirely on friction (that is, not driven to a fetch-up), I see no objection to the chestnut pile.

Mr. Osgood:—While it is true that chestnut is not a very strong wood and will split with very hard driving, it is a very successful pile under ordinary conditions.

Mr. C. P. Howard:—Is cypress intended to include all kinds of cypress? Mr. Nelson said there is a good deal of difference in cypress, red cypress perhaps being all right and others no good at all.

Mr. Nelson:—I move that after the word "and," in the last line of paragraph 1, "red or black cypress" be inserted. Red and black seem to be the kinds which are good and all others bad; at least, that

is the local understanding in Florida and Louisiana, where most of the cypress comes from. In the Carolinas they have all kinds—yellow, red, white, black, and even green, but none of it seems to be any good, except that which is known as red or black.

Mr. J. P. Snow (Boston & Maine):—I second the motion, and ask if the Committee will not insert chestnut in the list of timbers that are specified?

Mr. Downs:—I move we amend that by saying red, black or yellow cypress.

Mr. Courtenay:—It has been the experience of the Louisville & Nashville Railroad that what is called yellow cypress rots in about five years. The same road has used Louisiana black cypress, and it is still in the track and and good for a life of fifteen years.

Mr. E. H. Bowser (Illinois Central):—Numbers of yellow cypress ties have been in our track for nine years and are perfectly sound in dirt ballast.

Mr. Nelson:—I will state, in regard to yellow cypress, that in North Carolina there is a yellow cypress which, as Mr. Courtenay says, is only good for a few years. Our people have about concluded that any close-grained heart cypress is good, but we find there are many different names for the same kind of tree—for instance, black cypress in Florida may be the same as the yellow cypress Mr. Bowser speaks of. I believe that red and black are more generally known than any other cypress, and they are invariably good; at least that has been my experience.

The President:—The chair suggests that the resolution be separated and that one motion be made to include red or black cypress. The Committee does not feel they can accept that, but would accept the insertion of chestnut.

Mr. Nelson's motion that paragrach 1 be amended by inserting the words "red or black" before the word "cypress" is in order.

Mr. A. F. Robinson:—I would ask if it means there are two kinds of cypress, red cypress and black cypress, or if the two words mean the same material, having different names in different sections?

Mr. Courtenay:—I think the two names mean the same material, as far as I have been able to ascertain, in Louisiana and Florida.

Mr. Nelson:—I think they are one and the same tree, but sometimes timbermen call them by different names.

Mr. Snell:—Can we not include in that motion at this time shortleaf yellow pine piles?

The President:—If the mover of the motion will accept it, it will be in order.

Mr. Nelson:—I will consent.

Mr. Bainbridge:—There are two grades, one which will stand exposure in the air, and the other which will be confined in water all its life, or be used for temporary purposes. We allow any timber that will stand driving in the second grade.

Mr. Snell:—I do not understand why we should permit cypress, which is reported as good for nine years, to go into the first grade and altogether eliminates from the list shortleaf yellow pine, which I am quite certain is good for from twelve to fifteen years exposed.

Mr. Osgood:—Are we to understand that the first grade is to include only that which is durable in the atmosphere?

Mr. Bainbridge:—That is the intention.

Mr. Osgood:—It occurs to me that the discussion about shortleaf pine has a little to do with the range of climate. It is my understanding that the shortleaf pine in the South is not durable at all as a pile, while in the North, in water, it is fairly durable.

Mr. Bainbridge:—It is my impression that in the climate of New Orleans a shortleaf yellow pine tie is good for about from two to five years.

Mr. Snell:—I used shortleaf yellow pine piles which have been exposed nine years and are perfectly sound to-day, even to the sap portions.

Mr. Nelson:—I do not think there are many of our timbermen, unless they are extremely shrewd and bright, who can invariably tell the difference between longleaf and shortleaf pine, in the timber or in the logs, and even if we specify longleaf pine, quite a percentage of what we would get would be shortleaf, and not be longleaf.

Mr. C. P. Howard:—My impression is that shortleaf pine does not begin to last as long as cypress, which is one of the most lasting materials. I had no idea that shortleaf pine would be in the same class with red cypress as a pile.

(Mr. Nelson's amendment was lost.)

Mr. L. C. Fritch:—It seems to me if shortleaf pine was eliminated from that motion it might carry. I make a motion that the word "cypress" be qualified by "red or black cypress."

Mr. Bainbridge:—I second that motion. When I was with the Illinois Central we used to specify cypress, and I know the timber they got for piling was extremely good, one of the best-lasting timbers they had before they began to creosote. My impression is that most of what we got was yellow.

Mr. L. A. Downs (Illinois Central):—During the past three or four weeks I have made an examination of some red and yellow cypress in Mississippi, and I found without a doubt that the yellow cypress, cut in the Mississippi brakes, will last very nearly as long as the red cypress cut in Louisiana; I speak of ties. The same argument will hold for piling. We had one piece of track of which we had a good record, laid in 1898. The reason for the two different kinds being used was on account of a bridge, the ties being hauled from Louisiana at one end and the cypress brakes of Mississippi at the other end. This spring there were about 80 per cent. of the ties left in that track. There will be about 20 per cent. taken out this year, leaving about 60 per cent. of both kinds of ties in the track. On further examina-

tion of the ties in Mississippi, we had some reports that the ties did not last more than four or five years. We almost took that as conclusive that cypress ties from Mississippi would not last as long as those from Louisiana, but after an extended examination we found that it was due to the sap.

Going over a section of track where we have a record of the year in which it was built, we counted the number of ties that had been decayed in three years, and in the case of one track, of which I made a very thorough examination, 25 per cent. of them were decayed, the balance were good. In some new branch lines, where we had a perfect record of the year in which they were laid, some of the ties lasted from eight to ten years, and some of the ties we know are good for from twelve to fifteen years. They are Mississippi yellow cypress, and that is what governed me in making this motion to include yellow cypress, because I am satisfied that if it is heart it will last.

Mr. Wm. L. Hall (Forest Service):—If it is a good thing to encourage the use of several names for one kind of timber, then there would seem to be excellent reason for allowing the three descriptive adjectives to be put on cypress. But inasmuch as it is all one wood, and inasmuch as not only the railroads but manufacturers and others will profit by the use of one name that will apply in all parts of the country, would it not be better to not put on the qualifying words? They all refer to one kind of tree. There may be several types of it, a piece of timber that comes from one place may last longer than a piece that comes from another. The durability is largely determined by the amount of heart. My understanding is that all three names refer to a good, durable cypress of the same quality and it would not seem desirable to attach three names to the same quality of cypress.

Mr. Bowser:—I think there are about forty different varieties of cypress. White cypress can be white clear to the center of the tree, in which case it will not last two years, but in the case of the majority of the white cypress, if the heart is yellow, we call it yellow cypress. Nine-tenths of the cypress bought in this country is called red, but it is yellow. I believe that three-quarters of what we get from Louisiana is exactly the same cypress. If white cypress has a dark heart, we have proven on the Illinois Central that it is durable and makes a good timber for piling and ties. We get very little yellow cypress from Arkansas. I once examined a lot of piling from that state and found it was white to the center. I venture to say that two-thirds of the ties in the L. & N. tracks are yellow cypress ties.

The President:—The question is on Mr. Fritch's amendment to qualify "cypress" by the insertion of the words "red or black."

(Motion lost.)

The Secretary:—"3. All piles must be butt cut above the ground swell and have a uniform taper from butt to tip. Short bends will

not be allowed. A line drawn from the center of the butt to the center of the tip shall lie within the body of the pile."

Mr. Snell:—I consider a specification applying to white oak piles, which calls for a line drawn from center of butt to center of tip to remain within the body of the pile, an impossible one, particularly where the piling is to be as long as 50 feet and up. The Lackawanna recently endeavored to place an order for 100 white oak piles 50 feet and up in length and allowed one inch clearance of line stretched from center to center, and were unable to place the order until they allowed three inches clearance. I consider that in all cases the length of the pile should govern the crook to be allowed; that is, it should not apply on a 60-foot stick and a 30-foot stick alike.

Mr. Bainbridge:—The question was very carefully considered, and it was thought that more of a crook could be allowed in a short pile, which was relatively heavier, than in a long pile. As a matter of fact, the strength of the long pile is much more essential than that of the short pile. It will get harder driving. This is an old specification, in use many years. Before including it in the report, I went over 1,000 piles and had a couple of young men go over about 1,000 others, that were nothing but second-class piles, and there were not over 25 or 50 of these piles that would not fulfill the specification. They were maple, Norway, tamarack, red oak, and there were hardly any of them that would not fill the specification, and they were not bought with the intention of filling this requirement either.

Mr. J. A. Lahmer (Kansas City Southern):—How long were these piles?

Mr. Bainbridge:—All the way from 30 to 75 feet.

Mr. Snell:—Was there any white oak?

Mr. Bainbridge:—No, all second class. There were some long-leaf pine. These were almost absolutely straight.

Mr. Snell:—Are we working on specifications for first-class piles?

Mr. Bainbridge:—In that respect, the same specification covers both. It was considered that the driving of the pile was the essential feature. As regards straightness, it was considered that a second-class pile should be as nearly straight as a first-class pile.

The Secretary:—"4. Unless otherwise allowed all piles must be cut when sap is down. All piles must be peeled soon after cutting. All knots shall be trimmed close to the body of the pile.

"5. For round piles the minimum diameter at the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft.; eight (8) in. for lengths over thirty (30) ft. but not exceeding fifty (50) ft., and seven (7) in. for lengths over fifty (50) ft. The minimum diameter at one-quarter of the length from the butt shall be twelve (12) in. and the maximum diameter at the butt twenty (20) in."

Mr. Courtenay:—I move an amendment by adding one inch to the diameter of the small end in paragraph 5.

(Motion lost.)

The Secretary:—"6. For square piles the minimum width of any side at the tip shall be nine (9) in. for lengths not exceeding thirty (30) ft.; eight (8) in. for lengths over thirty (30) ft. but not exceeding fifty (50) ft., and seven (7) in. for lengths over fifty (50) ft. The minimum width of any side at one-quarter of the length from the butt shall be twelve (12) in.

"7. Square piles shall show at least eighty (80) per cent. heart on each side at any cross-section of the stick, and all round piles shall show at least ten and one-half (10½) in. diameter of heart at the butt.

"No. 2 R. R. Grade.—8. This grade includes red and all other oaks not included in No. 1 R. R. grade, sycamore, sweet, black and tupelo gum, maple, elm, hickory, Norway pine, or any sound timber that will stand driving.

"9. The requirements for size of tip and butt, taper and lateral curvature are the same as for grade No. 1.

"10. Unless otherwise specified piles need not be peeled.

"11. No limits are specified as to the diameter or proportion of heart.

"12. Piles which meet the requirements of grade No. 1 except the proportion of heart specified will be classed as No. 2."

Mr. L. C. Fritch:—I move that conclusion 3, relating to the revised specifications for timber piles, as amended, be approved.

(Motion carried.)

Prof. Jacoby:—By vote of the Association last year the question of standard names for structural timbers was referred back to the Committee, and as this matter is directly related to what has just been passed upon, the Committee reports conclusion 5 and asks for its consideration at this time. It reads: "That the standard names for structural timbers be approved." They were published in the Bulletin last year, and are also published in the Proceedings, Vol. 9. page 358. The Committee has given further consideration to the objections made last year and the year before and fails to see any reason why its position should be modified. The only point of difference raised was in regard to the subdivision of Southern yellow pine. The Committee report under this definition reads as follows:

"1. Southern Yellow Pine.—Under this heading three classes of timber are used: (a) longleaf pine, (b) shortleaf pine, (c) loblolly pine."

The Committee desires to report the conclusion that the standard names for structural timbers be approved in the form in which they were printed in the Proceedings.

Mr. L. C. Fritch:—I move that conclusion 5 of the Committee be adopted.

(Motion carried.)

Prof. Jacoby:—The next part of the report of this Committee

refers to the recommended safe unit stresses for structural timbers The report begins on page 15 and ends on page 37. A table which gives the final results of the investigations by the Committee extending over several years is given on page 37. An attempt has been made to study all tests that have been made in this country and Canada, as indicated in the bibliography published two years ago, and these have been very carefully studied and the results put in tabular form. The discussion in Appendix B points out the relation of the strength of the lowest 10 per cent. group of a given series of tests as compared with the average strength for the entire series. The relation of all the groups is shown on a number of diagrams. Last year a large number of diagrams were published indicating the present practice of the railroads with reference to unit stresses employed in designing wooden bridges and trestles. I move the adoption of conclusion No. 4, that the list of safe unit stresses for structural timber be approved.

Mr. Loweth:—I suggest the desirability of changing the expression, "safe stresses," wherever it occurs in the table and its footnotes, to "working stresses." The expression "safe stresses" might lead to the inference that anything in excess would be unsafe.

Prof. Jacoby:—The Committee will accept that.

Before voting on the motion relating to this conclusion I wish to make a statement on the necessity for a note to accompany the table of unit stresses when printed in the Manual, and for this reason: We all remember that when the excellent report of 1895 was made by a Committee of the American Association of Railway Superintendents of Bridges and Buildings, of which the late Mr. Berg was chairman, that the part of the report on unit stresses in the form of two tables was copied very widely, being published in hand-books, text-books and engineering periodicals throughout the world, and in many cases these results were used in a different way from that intended by the Committee. It seems, therefore, desirable that when this table is published in the Manual that a note should accompany it calling attention to certain points, so that it will not be used in a manner different from that intended by the Committee. The note reads as follows:

"Note.—The working unit stresses given in this table are intended for railroad bridges and trestles. For highway bridges and trestles the unit stresses may be increased twenty-five (25) per cent.

"For buildings and similar structures in which the timber is protected from the weather and practically free from impact, the unit stresses may be increased fifty (50) per cent.

"To compute the deflection of a beam under long-continued loading instead of that when the load is first applied, only fifty (50) per cent. of the corresponding modulus of elasticity given in the table is to be employed."

The President:—The suggestion of Prof. Jacoby will be received as information, and the question now is upon the adoption of this conclusion as amended.

(Motion carried.)

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—Mr. Fritch made a motion a while ago that conclusion 3, as revised, be approved. My recollection is that all amendments were defeated.

Mr. Fritch:—Excepting that chestnut was included.

Mr. Wendt:—What does the Committee desire included in the Manual with reference to conclusion 4?

Prof. Jacoby:—It is intended that the table on page 37 of Bulletin 107 be printed in the Manual, with the addition of the note which was read a few moments ago, and with the modification suggested by Mr. Loweth, which was accepted by the Committee, to change "safe stresses" to "working stresses."

Mr. Wendt:—In Vol. 9 of the Proceedings, page 358, how much of the next do you want included?

Prof. Jacoby:—The standard names for structural timbers are also to go into the Manual. There is one other item to which we wish to call your attention. The last part of the report consists of the subject of piles and pile-driving, and we desire to report, as the result of a conference of the Committee this morning, a few modifications in the definitions.

I move that conclusion 4 be adopted.

(Motion carried.)

The President:—The Committee will be excused with the thanks of the Association.

Mr. W. K. Hatt (by letter):—The three committees, namely, of this Association, the American Society for Testing Materials, and the Yellow Pine Manufacturers, are still at variance upon these specifications. The outstanding differences, however, are not serious. They are mainly: (a) the trade names for Southern pines, and (b) general requirements.

(a) No mention is made in the Committee's report of the unsettled question of the trade names for the Southern pines. The writer's view is that the classification of the American Society for Testing Materials should be adopted. This contemplates: (1) longleaf pine; (2) shortleaf pine. These names are not specific, but refer to a quality which should be specified. The writer believes it is admitted that few experts can distinguish, with certainty, intermediate and suitable timbers of these species. Extreme forms are easily distinguishable. A practical way, in the writer's view, is to specify two classes and distinguish these upon the basis of limits of growth; that is, rings per inch. The upper limit of growth would separate the longleaf from the shortleaf, and the lower limit would exclude unsuitable shortleaf or loblolly. The inspection of timber would, in all

cases, be based upon this limit, used in conjunction with the general requirement of timber.

The Committee of the American Society for Testing Materials has been working on the problem of these limits of growth. It is understood that Dr. Von Schrenk has gathered the necessary information.

The writer believes the specifications for structural timber are about right, except the general requirements, which should be rewritten as follows:

"Except as noted, all timber shall be cut from sound trees, sawed standard size, true and straight, square edged, and practically out of wind; close grained, solid, and free from defects such as injurious ring shakes and cross grain, unsound or loose knots, knots in groups, decay, large pitch pockets, or other defects that will materially impair its strength."

This modifies the Committee's general requirements by arranging the items in a more logical order and inserting "practically" before "out of wind," and also the use of the term "cross grain," instead of "crooked grain."

The sheets accompanying the Committee's report are valuable. It should be noted, however, that in Sheet 19 and the following the moisture content is not stated in the case of many of the experiments. The discrepancy of the experiments is not as great as might be assumed from the exhibitions upon these sheets. It is probable that the differences between the lower and upper limit are to be accounted for by the difference of moisture content.

The sheets in general show that little value attaches to tests of small samples from the standpoint of use of results in structural design. It is a singular fact, however, that some of the noted scientists of Europe oppose such tests on large sticks. *One objection is that such sticks contain defects!*

Dr. Hermann Von Schrenk (by letter) :—In looking over the Committee's report, the writer finds no mention of the question reassigned to the Committee last year with reference to the names for Southern pines. In the report of the American Society for Testing Materials, adopted by the Society a year ago, it was recommended, in view of the fact that even the best experts cannot, with any degree of certainty, distinguish the various botanical species of Southern pines after these have been manufactured into lumber and timbers, that for practical purposes Southern pines be classified into shortleaf and longleaf pines.

The writer has for a good many years been trying to find some definite basis for distinguishing the various groups of Southern pines, which should be of such character that it would not require a technical expert to distinguish them. As the result of a great many measurements made in the various sawmills of the Southern States during the last two years, the writer recommended that the various classes of

Southern pines be distinguished on the basis of the number of growth rings per inch, as measured in an average of five (5) in. when the rule is held from the center of the stick outward. As the result of many measurements, details of which will be communicated to the American Society for Testing Materials at the next annual meeting, it is recommended that that timber which has fifteen (15) growth rings per inch or more as measured in an average of five (5) in. across the face of the stick, shall be considered longleaf pine; any timber having less than this number of growth rings shall be considered shortleaf pine. If for any reason it is desired to classify shortleaf pine into shortleaf and loblolly, such sticks shall be considered shortleaf as have an average of eight (8) rings and less than fifteen (15) rings per inch, and all with less than eight (8) rings per inch, shall be considered loblolly.

In making this suggestion the writer is aware that these figures must be considered tentative, but believes that they are close approximations. It is pointed out that the factors for distinguishing the Southern pines in making specifications for structural material are, first, strength requirements, and, second, requirements of durability. It has been determined with a fair degree of exactness that the densest sticks are usually the strongest, and the more porous sticks the weakest. The number of pieces of botanical shortleaf or botanical loblolly with more than fifteen (15) rings per inch will be very few, and such as do have that number, will be found to be the sticks of maximum strength of either shortleaf or loblolly species.

The method of distinguishing the Southern pines by means of growth rings is an easy method, and one which anybody can readily understand and apply. It is simpler than the most exact scientific methods of distinguishing these species botanically, and while some mistakes will be made in applying this rule, it can be stated with equal certainty that mistakes are made in applying rigid botanical specifications. That even the most exact microscopic methods are not always to be depended upon is well shown in a recent publication, "North American Gymnosperms," by Dr. D. P. Penhallow, probably the leading authority on the microscopic character of American woods, who in applying the key for determining the different species of wood, selected a number of test specimens both from hardwoods and pines. Of this final test he says in the introduction of the volume: "A final application of the test specimens under the precise conditions which would obtain in ordinary practice showed a verification of 91.5 per cent. for all genera and species. In this connection, it may be of interest to note that the greatest sources of error were to be found in the second section of the genus Pinus (pines)*, particularly in P. tæda (loblolly pines), P. echinata (shortleaf pine), and P. glabra (spruce pine) in the order given, whence it appears that these species stand out as the most variable of the entire coniferales (pine family), and, on the whole, the most difficult to determine." The writer has quoted from this volume thus

extensively because this quotation shows better than any lengthy argument, coming as it does from the highest authority in this country, that even with the most exact microscopic methods it is a hazardous thing to try to distinguish pieces of wood of the Southern pines with any degree of certainty and exactness. If this cannot be done microscopically, how can we expect the engineer and timber inspector to classify these timbers by merely looking at them.

The specification in which Southern pines are distinguished on the basis of eight (8) rings per inch is now being tried on the Rock Island, Frisco and Chicago & Eastern Illinois systems, and the writer would urge upon the Committee the desirability of giving this system of distinguishing the Southern pines a trial until some better method can be found.

(Thursday morning session.)

The President:—The chair will ask unanimous consent to allow Prof. Jacoby, chairman of the Committee on Wooden Bridges and Trestles, to occupy a few moments of your time to make a statement.

Prof. Jacoby:—Mr. President, the matter relates to the designation of the two grades of yellow pine timber, the specifications for which were adopted by the Association yesterday. At our conference with the representatives of the other associations last July the committees agreed upon these designations: "No. 1 R. R." and "No. 2 R. R."

At the January meeting of the Yellow Pine Manufacturers' Association their committee was not upheld by the convention, on the ground it would cause confusion with the names of existing grades, which could not possibly be tolerated. That association then adopted the names "No. 1 R. R. Heart" and "No. 1 R. R." That was objectionable to our Committee for the reason that there are two No. 1's, and if the word "heart" were overlooked in some way it would cause confusion.

This matter was considered in a conference the other evening before we reported, but no suggestion seemed to meet with approval on both sides. Yesterday, however, after our Committee reported to the Association, another conference was held, when the suggestion was adopted to call the first grade "R. R. Heart" and the second grade "R. R. Falsework." Permission is therefore requested to make this change before the designations are printed.

A suggestion was made to substitute "temporary work" for "falsework," but there are objections to this term, for the reason that some of this material may be put under the water in foundation work, and which might remain permanently.

We simply ask unanimous consent to have the proposed changes made in the designations of the two grades.

(The President put the question of granting such unanimous consent and consent was so granted.)

REPORT OF COMMITTEE NO. XVII—ON WOOD PRESERVATION.

(Bulletin 107.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

INSTRUCTIONS TO COMMITTEE.

The instructions to the Committee were:

(1) *To cover in general the investigating and reporting on the preservation of wood used for ties and for railroad structures and buildings, confining the work of the Committee more particularly to processes, methods and results obtained.*

(2) *To present a recommendation as to outline of work for the Committee, with suggestions for classification to be followed.*

(3) *Continue the work done heretofore by the Committees on Ties and on Wooden Bridges and Trestles relating to the special subjects of processes and methods of wood preservation.*

MEETINGS HELD AND PREPARATION OF REPORT.

A meeting of the Committee was held in Chicago on May 6 for the purpose of determining on organization and the character of the work to be done. The following members were present: Carl G. Crawford, R. N. Begien, O. Chanute, Geo. M. Davidson, V. K. Hendricks, S. M. Rowe, F. J. Angier (representing T. E. Calvert), A. L. Kuehn.

The Sub-Committees determined on were as follows:

A. *Statistics and Economics:* O. Chanute, *Chairman;* W. H. Courtenay, E. B. Cushing, T. E. Calvert.

B. *Preservatives:* Dr. Hermann Von Schrenk, *Chairman;* E. O. Faulkner, Geo. M. Davidson, W. W. Curtis.

C. *Adaptability of Woods and Their Preparation:* Dr. W. K. Hatt, *Chairman*; S. M. Rowe, E. Stimson, C. K. Conard.

D. *Treating Processes:* Carl G. Crawford, *Chairman;* R. N. Begien, L. Bush, V. K. Hendricks, A. L. Kuehn.

The second meeting was held August 26 in Chicago for the purpose of reporting progress, at which the following members were present: L. Bush, T. E. Calvert, O. Chanute, W. W. Curtis, Geo. M. Davidson, W. K. Hatt, Carl G. Crawford, A. L. Kuehn.

The work of preparing the final report was carried on by correspondence and conference with individual members.

INTRODUCTORY.

The subject of preservation of wood is not yet, and may not for a long time, be placed on a complete scientific basis, that is, it is not possible to predict by scientific means the result of new and particular processes. In its present state the study of wood preservation is primarily one of results already obtained, particularly the studying of American results obtained under the conditions under which timber treated in the future will be used. It is vital, therefore, to obtain full and correct statistics, because these will form the basis of future work. From this it can be seen that the highly important part of the work of the Committee on Wood Preservation will be the gathering of statistics, together with the complete analysis of them. This can essentially be made one department of the committee work. From results already obtained the economic value of methods and processes can be determined. It was therefore decided to appoint a Sub-Committee on Statistics and Economics.

A thorough study of the preservatives or chemicals which have been used with known results is necessary in order that the known results may be reproduced. Furthermore, a detailed study of these preservatives will unquestionably result finally in the full determination of the action which these preservatives produce and thus make it possible to say why certain chemicals or compounds do preserve, thus forming a scientific basis for the whole subject. It is also essential that practical requirements be determined upon for preservatives, resulting in proper specifications. It was determined that this study should be assigned to a sub-committee and therefore the Sub-Committee on Preservatives was established.

In the practical execution of wood preservation numerous problems occur, all of which are not yet on a proper basis. Experience has demonstrated that woods vary greatly in their receptibility of preservatives. This is found to be a serious problem in the operation of a timber preserving plant, and its proper solution is essentially a problem for this Committee. Wood needs proper preparation in order to be successfully treated. This preparation often has serious effects on the wood itself. Furthermore, the application of the preservative may itself affect the wood in strength and durability. This brings out the fact that it is necessary to study the wood itself in the course of its preservation. This work was assigned to a Sub-Committee on the Adaptability of Woods and their Preparation.

The study of practical modern methods of treating timber means the study of successful plants and the methods pursued in different processes. This is essentially a study and analysis of modern methods of doing the work, and this can be assigned to an individual sub-committee; therefore, the Sub-Committee on Treating Processes was appointed.

The work of the Committee so far has fully determined that many

facts are known, but these facts have not been compiled or brought together in the form to be most useful. There are a great number of statements given out as facts which are not proven. The Committee, in its first year, recognizing the responsibility which rests with it and feeling that the work of its first year should be primarily an analysis, refrains in general from presenting matter to the Association for positive action, excepting in a few minor cases. The report, therefore, in general contains facts, statements and analyses for the foundation of future work.

(A) STATISTICS.

Thirty-nine members of this Association were selected who were likely to possess information. The Committee was extremely fortunate, receiving thirty-six answers. These are summarily abstracted in Table I. This table must be taken as giving information so far obtained. It is not conclusive and will in the future be revised and enlarged. Some preliminary deductions may, however, be made, but it is realized that modifications may result from further reports. The statements as given will be seen to date back to 1851. The detailed reports have been filed in the Association office and are open for reference.

(1) Creosoting may be relied upon to preserve piles from 20 to 25 or more years if they are injected with 16 to 24 lbs. per cubic foot. See instances 2, 3, 6, 7, 11 and 22. (Instance 2 is given in full in Appendix A.)

(2) Creosoting at present cannot be relied upon to preserve ties more than 15½ (instance 3) to 19 years (instance 5), an absolute maximum, unless the ties are protected against mechanical destruction. If badly injected, they perish from decay in 5 to 12 years (instance 13).

(3) Burnettizing when well done can be relied upon to preserve ties from 10 to 14 years. The amount to be injected varies with the proposed subsequent exposure. In arid climates ¼-lb. of dry zinc chloride per cubic foot may give good results. In moist and warm climates not less than ½-lb. per cubic foot should be injected. (See instances 7, 8, 9, 10, 12, 15-B and 21.) There are great differences in the thoroughness with which the work can be done, as shown by instances 16, 27, 37. See also in Appendix B the difference between good and bad work.

(4) The Zinc-Creosote process has been too recently introduced (1904) in this country to give definite conclusions; it has given ties a life of 12 to 18 years in the track in Germany.

(5) The Rueping and the Lowry processes are too recent to form definite opinions as to the resulting life of ties.

(6) Great waste and disappointment will result unless accurate records are kept, for ten years at least, of the results in the track, connecting them with the way in which the work has been done. The best method of identification is by dating nails.

TABLE I.

No.	Name.	Date of Letter.	Road, Etc.	Yr.	Process.	What Treated.	Kind of Wood.	Lbs. per Cu. Foot.	Results.	Mode of Failure.	No.
1	C. H. Ewing	7-20-08	Phila. & Read.	1851	Kyanizing	Track ties	Not stat'd		Wood preserved.	Strength reduced	1
1	C. H. Ewing	7-20-08	Phila. & Read.	1852	Tar Treatment	Track ties	Not stat'd		Not preserved	Caused dry rot	1
1	C. H. Ewing	7-20-08	Phila. & Read.	1867	Burnettizing	305,107 track ties	Not stat'd		Partly preserved.	Brittle and broke	1
2	W. H. Courtenay	6- 2-08	L. & N	1876	Creosoting	Stringers	L. L. Pine	16 lbs	Sound after 24 yr	Some washed away	2
2	W. H. Courtenay	6-23-08	L. & N	1876	Creosoting	50,000 piles	L. L. Pine		25 years life	Some washed away	2
2	W. H. Courtenay	6-23-08	L. & N	1878	Creosoting	15,000 bridge ties	Pine	12-18 lbs.	45% to 55% still in 1896	Some washed away	2
2	W. H. Courtenay	6-23-08	Pensacola Dock	1882	Creosoting	Wharf timber	Pine	16-18 lbs.	Attacked by toredo	Some still in use 1908	2
2	W. H. Courtenay	7-16-08	L. & N	1879	Creosoting	1893 bridge ties	Pine	20-22 lbs.	533 in June, 1905 28%	Rail cut and spike killed	2
3	J. O. Osgood	7- 3-08	C of N. J	1876	Creosoting	5,000 track ties	Hemlock	12 lbs	Life 15½ years	Cut by rail	3
3	J. O. Osgood	7- 3-08	C. of N. J	1896	Creosoting	50,000 track ties	Y. Pine	12 lbs	Life not stated	Cut by rail	3
3	J. O. Osgood	7- 3-08	C. of N. J	1892	Creosoting	Piles and timber	Y. Pine		Life 20 years		3
4	J. P. Snow	7- 7-08	B. & M	1884	Kyanizing	100,000 ties	Hemlock	Varied	Life 10-14 years	Splinter and sliver	4
5	E. B. Cushing	6-21-06	H. & T. C. Ry.	1880	Creosoting	150,000 ties	Pine	10 lbs	Life 19 years	11,282 in track in 1906. Railworn	5
6	E. B. Cushing	10- 1-08	Galveston Bay	1875	Creosoting	4,000 piles or more	Pine	8 lbs	No record of life.	Destroyed by teredo	6
6	E. B. Cushing	10- 1-08	Galveston Bay	1875	Creosoting	150 piles or more.	Pine	24 lbs	Life 20 years or more	17 lbs. oil per cu. ft. found by Alleman 1904.	6
7	D. K. Colburn.	8-25-08	Texas & N. O	1888	Burnettizing	10,500,000 ties	Pine	0.25 lbs.	Life 10-11 years.	Decay	7
7	D. K. Colburn.	8-25-08	Texas & N. O	1888	Creosoting	77,500,000 F B M	Pine	2½ gal	For piles, 25 yrs.	Occasional bad treatment	7
7	D. K. Colburn.	8-25-08	Texas & N. O	1888	Creosoting	Piles and timber.	Pine	1½ gal	For timber, 25 years	Occasional bad timber	7
8	F. O. Faulkner	8-18-08	A. T. & S. F	1885	Burnettizing	15,096,561 ties	Pine	.25 to .5 lb.	Life 10.55 years	10.8 to 14.9 in dry regions	8
8	E. O. Faulkner	8-18-08	A. T. & S. F	1906	Rueping	2,176,417 ties	Pine	4½ to 5 lb.	Too recent		8
9	R. L. Huntley.	7-14-08	Union Pac	1886	Zinc-Tannin	150,000 ties	Hemlock	0.30 lb.	Life 12-15 years	Rail worn	9
10	O. Chanute	8- 8-08	C. R. I. & P	1886	Zinc-Tannin	5,641,731 ties	Hemlock	.25 to .5 lb.	10¾ years east of Missouri River 11.7 yrs. west.	Decay and rail cutting.	10
11	J. H. Wallace	6-27-08	So. Pac	1889	Creosoting	70,000,000 feet piles and ties	Pine	10 lbs	Life 20 years	Few failures	11
11	J. H. Wallace	6-27-08	So. Pac	1895	Burnettizing	12,000,000 ties	Pine-Fir	.27 lb.	Life 10-12 years	Checking and dry rot	11
12	R. Angst	10-19-06	D. & I. R	1891	Zinc-Tannin	256 ties	Various	.50 lb.	74% in after 15 years	Rail cutting	12
13	T. E. Calvert.	7-29-08	C. B. & Q	1869	Creosoting (Seeley)	25,000 ties	Hemlock	1-inch	Life 5 to 12 years	Dry rot	13
13	T. E. Calvert.	7- 8-08	C. B. & Q	1899	Burnettizing	4,836,668 ties	Pine-Fir	.35 to .5 lb	Est. life 10-12 yr.	Rot when covered with earth	13
14	R. H. Howard.	1-31-08	C. & E. I	1899	Zinc-Tannin	1,929,855 ties	Oak	.50 lb.	Est. life 14 yrs.	See detail	14
15A	R. Trimble	7- 3-08	Penna. Lines	1896	Zinc-Tannin	63,187 ties	Various	.50 lb.		Decay	15A

15B	W. C. Cushing.	7- 6-08	Penna. Lines..	1897	Zinc-Tannin.....	126,973 ties	Various...	.50 lb.....	Est. life 12 years.	Decay and rail cutting.......	15B
16	S. B. Fisher...	6-29-08	M. K. & T.....	1901	Zinc-Tannin.....	1,300,612 ties....	Sap pine..	....	22% out in 6 yrs.	Changed to Burnettizing......	16
16	S. B. Fisher...	6-29-08	M. K. & T.....	1903	Burnettizing....	1,844,759 ties....	Sap pine..	....	3.4% out in 4 yr.	Changed to Rueping..........	16
17	A. H. Hogeland	12-16-08	Gr. Nor.......	1901	Zinc-Tannin....	Cross ties.......	Tamarack -Spruce	.78 lb....	Too recent......	No failures.....	17
17	A. H. Hogeland	12-16-08	Gr. Nor......	1904	Burnettizing....	Cross ties.......	Pine-Fir.	.78 lb....	Too recent......	No failures.....	17
18	E. O. Faulkner	....	Exper in Texas	....	....	....	....	....	....	....	18
19	J. B. Berry....	11- 9-08	C. R. I. & P...	1886	Zinc-Tannin....	Cross ties.......	Hemlock.	.50 lb....	11 years life	....	19
19	J. B. Berry....	11- 9-08	C. R. I. & P...	1907	Creosote........	Timber and ties.	Gum-Beech	6.80 lbs...	Too recent......		19
20	G. M. Davidson.	8- 5-08	C. & N. W....	1903	Burnettizing....	2,184,336 ties.....	Hemlock.	.50 lb....	Too recent......		20
20	G. M. Davidson.	8- 5-08	C. & N. W....	1908	Zinc-Creosote....	Ties............	Various..	....	Too recent......	....	20
21	C. W. Berry to	7-14-08	Union Pac....	1902	Zinc-Chloride....	Ties............	Pine-Fir..	.25 lb....	10-12 years life..	See No. 9.......	21
	R. L. Huntley	7-14-08	Union Pac....	1902	Creosoting......	Piles...........	Pine-Fir..	....	....	....	21
22	H. R. Safford..	8-22-08	Ill. Central....	1903	Zinc-Chloride....	5,876,173 ties....	Oak and beech..	.50 lb....	8-10 years life est	....	22
22	H. R. Safford..	8-22-08	Ill. Central....	1903	Creosoting......	Piles and timber.	Pine......	14-18 lbs..	25-30 yrs. life est.	Favors Rueping.	22
23	C. F. Loweth..	9- 5-08	C. M. & St. P..	1904	Creosoting......	Piles and timber.	Pine......	12-16 lbs..	Too recent......	....	23
23	C. F. Loweth..	9- 5-08	C. M. & St. P..	1902	Burnettizing....	Ties............	Pine......	.30 lb....	Too recent......	....	23
23	C. F. Loweth..	9- 5-08	C. M. & St. P..	1905	Rueping........	Ties............	Pine......	5 lbs.....	Too recent......	....	23
24	W. D. Taylor..	11- 5-08	T. St. L. & W..	1905	Burnettizing....	500,000 ties.....	Various..	.50 lb....	Too recent......	....	24
25	G. W. Boschke	7- 2-08	Ore. Ry. & Nav.	1904	Burnettizing....	Piles, timber, ties	Douglas Fir.....	.25 lb....	Too recent......	....	25
25	G. W. Boschke	7- 2-08	Ore. Ry. & Nav.	1906	Creosoting......	1,395,975 ties 212,006 FBM..	Douglas Fir.....	8-10......	Too recent......	Caps weakened..	25
26	A. L. Kuehn...	6-27-08	C.C.C.& St.L..	1904	Zinc-Creosote....	693,324 ties.....	Oak and gum....	.50 lb....	Too recent, est. 11-12 years...	....	26
26	A. L. Kuehn...	6-27-08	C.C.C.& St.L..	1904	Lowry Process...	1,650,000 ties....	Oak and gum....	6.3 lbs...	Too recent, est. 16 years......	....	26
27	W. D. Taylor..	8-13-08	C. & A........	1900	Burnettizing....	450,000 ties.....	Various...	....	Some decayed in 3 or 4 years...		27
27	W. D. Taylor..	8-13-08	C. & A........	1900	Creosoting......	Piles and timber.	Y. Pine..	....	Good after 8 yrs.	....	27
28	M. L. Lynch..	7- 7-08	St. L. & S. W.	1905	Zinc-Creosote....	Ties............	S. L. Pine.	.24 lb zinc 3 lbs creo	Too recent......	....	28
28	M. L. Lynch..	7- 7-08	St. L. & S. W.	1905	Creosoting......	Piles and timber.	S. L. Pine.	12 lbs....	Too recent......	....	28
29	L. Bush.......	7- 9-08	D. L. & W....	1905	Creosoting......	12,000 bridgeties	Y. Pine..	12 lbs....	Too recent......	....	29
29	L. Bush.......	7- 9-08	D. L. & W....	1907	Creosoting......	8,000 track ties..	Y. Pine..	12 lbs....	Too recent......	....	29
30	Wm. McNab..	7-29-08	Grand Trunk.	1903	Burnettizing....	255,574 ties.....	Red Oak.	....	Too recent, 10 yr.	....	30
31	W. L. Darling.	9- 5-08	Nor. Pac......	1907	Creosoting......	94,694 ties......	Various...	7 lbs.....	Too recent......	....	31
31	W. L. Darling.	9- 5-08	Nor. Pac......	1907	Creosoting......	Timber.........	Various...	15 lbs....	Too recent......	....	31
32	J. M. Meridith.	6-29-08	Flor. E. Coast.	1907	Creosoting......	16,000 ties......	Pine......	....	Too recent......	....	32
33	W. H. Moore..	....	N.Y.N.H.& H.	....	....	....	....	....	....	....	33
34	J. F. Hinckley.	11- 7-08	St. L. & S. F..	1905	Rueping........	332 ties.........	Red Oak.	5 lbs.....	Too recent......	....	34
34	J. F. Hinckley.	11- 7-08	St. L. & S. F..	1906	Rueping........	1,107 ties.......	R. Oak and gum.	4 lbs.....	Too recent......	....	34
35	A. F. Rust....	8-29-08	K. C. Southern	1904	Creosoting......	....	Pine......	12 lbs....	Too recent......	....	35
36	E. B. Ashby...	8- 7-08	Lehigh Valley.	1886	Creosoting......	Piles, timber, ties	Oak and pine...	8-12 lb...	Over double life..	....	36
37	A. O. Cunningham.......	10-17-08	Wabash.......	1903	Burnettizing....	Ties............	Red Oak.	.513 lb...	Life 5 to 6 years.	Rail cuts — are brittle.	37
38	T. E. Calvert..	9-18-08	C. B. & Q.....	1902	Hasselman......	37,999 ties......	Pine......	....	Dead failure.....	....	38
38	T. E. Calvert..	9-18-08	C. B. & Q.....	1902	Hasselman......	15,597 ties......	Fir.......	....	Dead failure.....	....	38

(7) It is indicated by the statistics given that a treated tie or timber may be destroyed by mechanical action long before it is decayed. The present general American method of rail fastening is not ample and not efficient. It is essential in order to obtain the full economic life of a preserved tie to improve the fastening by providing greater bearing surface and by the use of screws or screw spikes.

(B) PRESERVATIVES.

The work on preservatives is necessarily progressive. The Committee does not wish to present at this time a detailed study of preservatives in general. It was determined to limit the work this year to coal-tar creosote and chloride of zinc, which are now being commonly used.

The increasing demand for coal-tar creosote has shown the necessity for the adoption of some standard specification. At the present time a considerable number of different specifications for this substance are in use (see Vol. 9, p. 740, of the Proceedings). These differ mainly with respect to the amount of low-boiling fractions permitted, and they differ, furthermore, in the manner in which the constituents of the coal-tar creosote are stated. Some specifications specify certain definite percentages of compounds, while others refer to definite quantities of fractions obtained in distilling the creosote, making no specific reference to individual compounds.

The chief requisite for a successful coal-tar creosote, i. e., one which shall preserve wood for an indefinite period of time, should be that the oil be composed of compounds which, because of their high-boiling points, will guarantee the greatest possible stability. Taking the oils as they are now manufactured, the endeavor should be to reduce the low-boiling fractions as far as possible, consistent with obtaining an oil which shall be fluid enough at all working temperatures to obtain a thorough and equal penetration throughout the mass of the wood cells. This means that it is found advisable to omit any definite reference to individual compounds in any specification for creosote oil. The correctness of this conclusion is sufficiently demonstrated by the fact that there appears to be no agreement among those who have used creosote oil for a long period of years as to which compound or compounds are to be considered as specifically important in increasing the preservative value of coal-tar creosote.

With this end in view the following specification is recommended (see Appendix F, report of Tie Committee, Vol. 9, of the Proceedings). The principal points in connection with this specification are that it leaves out of consideration the question of relative properties of compounds and dwells essentially upon the necessity of obtaining fractions of a high-boiling character, as determined by fractional distillation:

STANDARD SPECIFICATION FOR COAL-TAR CREOSOTE.

The oil used shall be the best obtainable grade of coal-tar creosote; that is, it must be a pure product of coal-tar distillation and must be free from admixture of oils, other tars or substances foreign to pure coal tar; it must be completely liquid at thirty-eight (38) degrees Centigrade, and must be free from suspended matter; the specific gravity of the oil at thirty-eight (38) degrees Centigrade must be at least 1.03. When distilled according to the common method, that is, using an eight (8) ounce retort, asbestos covered, with standard thermometers, bulb one-half (½) in. above the surface of the oil, the creosote, calculated on the basis of the dry oil, shall give no distillate below two hundred (200) degrees Centigrade, not more than five (5) per cent. below two hundred and ten (210) degrees Centigrade, not more than twenty-five (25) per cent. below two hundred and thirty-five (235) degrees Centigrade, and the residue above three hundred and fifty-five (355) degrees Centigrade, if it exceeds five (5) per cent. in quantity, must be soft. The oil shall not contain more than three (3) per cent. water.

SPECIFICATION FOR ZINC-CHLORIDE.

The zinc-chloride used shall be as free from any impurities of any kind as is practicable, being slightly basic and free from free acid.

METHODS FOR MEASURING COAL-TAR CREOSOTE.

The Committee finds that there are a good many different methods in use at the present time for determining the amount of creosote both as received at the treating plants and as absorbed by the timber. These differences relate largely to different temperatures at which oil is measured. Some state the number of gallons of oil received or used at 60 degrees F., others at 100 degrees F., others at 110 degrees F., etc., etc. This has given rise to a good deal of confusion, and as there appears to be no good reason why there should be so many different standards, the Committee recommends that the standard temperature at which oil should be stated as 100 degrees F. At this temperature practically all creosote oils in common use are liquid and can therefore be readily measured.

In view of the fact that coal-tar creosote is used at temperatures other than 100 degrees F., i. e., either above or below 100 degrees F., it is necessary to reduce the volume at any observed temperature to the standard volume at 100 degrees F. The factor which is almost universally in use at the present time for making volume corrections is one per cent. (1%) expansion or contraction in volume for every 22½ degrees.

In making corrections for volume it is exceedingly important to state a volume at a standard temperature as indicating one hundred per cent., i. e., a unit volume. If this be taken at 100 degrees F., this will mean that oil at a temperature of 122½ degrees F. will be 101 per cent. of

the volume at 100 degrees F. In the same manner oil at 77½ degrees F. will be 99 per cent. of the volume at 100 degrees. Bearing this in mind and taking the temperature at 100 degrees as the standard, the following table is submitted to be used in converting the volume at any of the temperatures ordinarily obtained to the standard volume at 100 degrees F.:

Table II.

FACTORS TO BE USED FOR DETERMINING THE VOLUME OF CREOSOTE OIL AT 100 DEGREES F., WHEN THE OIL IS AT TEMPERATURES RANGING BETWEEN 60 TO 225 DEGREES F.

Temp. Fahr.	Factor.	Temp. Fahr.	Factor.	Temp. Fahr.	Temp.	Temp. Fahr.	Factor.
60	0.9822	102	1.0009	144	1.0196	186	1.0382
1	0.9827	3	1.0013	5	1.0200	7	1.0387
2	0.9831	4	1.0018	6	1.0204	8	1.0391
3	0.9836	5	1.0022	7	1.0209	9	1.0396
4	0.9840	6	1.0027	8	1.0213	190	1.0400
5	0.9845	7	1.0031	9	1.0218	1	1.0404
6	0.9849	8	1.0036	150	1.0222	2	1.0409
7	0.9853	9	1.0040	1	1.0227	3	1.0413
8	0.9858	110	1.0045	2	1.0231	4	1.0418
9	0.9862	1	1.0049	3	1.0236	5	1.0422
70	0.9867	2	1.0053	4	1.0240	6	1.0427
1	0.9871	3	1.0058	5	1.0245	7	1.0431
2	0.9876	4	1.0062	6	1.0249	8	1.0436
3	0.9880	5	1.0067	7	1.0253	9	1.0440
4	0.9885	6	1.0071	8	1.0258	200	1.0445
5	0.9889	7	1.0076	9	1.0262	1	1.0449
6	0.9894	8	1.0080	160	1.0267	2	1.0453
7	0.9898	9	1.0085	1	1.0271	3	1.0458
8	0.9902	120	1.0089	2	1.0276	4	1.0462
9	0.9907	1	1.0094	3	1.0280	5	1.0467
80	0.9911	2	1.0098	4	1.0285	6	1.0471
1	0.9916	3	1.0102	5	1.0289	7	1.0476
2	0.9920	4	1.0107	6	1.0294	8	1.0480
3	0.9925	5	1.0111	7	1.0298	9	1.0485
4	0.9929	6	1.0116	8	1.0302	210	1.0489
5	0.9934	7	1.0120	9	1.0307	1	1.0494
6	0.9938	8	1.0125	170	1.0311	2	1.0498
7	0.9943	9	1.0129	1	1.0316	3	1.0502
8	0.9947	130	1.0134	2	1.0320	4	1.0507
9	0.9951	1	1.0138	3	1.0325	5	1.0511
90	0.9956	2	1.0143	4	1.0329	6	1.0516
1	0.9960	3	1.0147	5	1.0334	7	1.0520
2	0.9965	4	1.0151	6	1.0338	8	1.0525
3	0.9969	5	1.0156	7	1.0343	9	1.0529
4	0.9974	6	1.0160	8	1.0347	220	1.0533
5	0.9978	7	1.0165	9	1.0351	1	1.0538
6	0.9983	8	1.0169	180	1.0355	2	1.0542
7	0.9987	9	1.0174	1	1.0360	3	1.0547
8	0.9992	140	1.0178	2	1.0365	4	1.0551
9	0.9996	1	1.0183	3	1.0369	5	1.0556
100	1.0000	2	1.0187	4	1.0373	....	....
1	1.0004	3	1.0192	5	1.0378	....	....

Explanation—To determine the volume at 100 degrees Fahrenheit, divide the volume at any temperature by the factor corresponding to that temperature in the above table.

In recommending the factor of one per cent. (1%) expansion or contraction for every 22½ degrees Fahrenheit, the Committee recognizes that the extent to which any oil will expand or contract will vary, to a certain extent, with the composition of the oil, and it will furthermore vary for different parts of the thermometer scale, i. e., the coefficient of expansion or contraction from 60 to 80 degrees is not necessarily the same as from 160 to 180 degrees. While recognizing this

variation, it has been found after an examination of a large number of oils that the factor recommended is sufficiently accurate for all practical purposes at this time.

MEASUREMENT OF COAL-TAR CREOSOTE BY WEIGHT.

The measurement of creosote by volume is always subject to more or less variation, owing to errors obtained in measuring large quantities, and in converting volumes as measured at a given temperature to the standard at 100 degrees F. It is suggested, therefore, that wherever possible oil quantities be measured by weight. If desired, the volume can then be determined by ascertaining the specific gravity. That this is perfectly practicable is shown by one of the large oil producers who ships all oil by weight.

(C) ADAPTABILTY OF WOODS.

The Committee limited itself in the work on the adaptability of woods and their preparation to the grouping of species and the strength of treated timber. The discussion is carried out as follows:

(1) *Grouping of Species.*

(a) Controlling factors.

(b) Wood structure.

Mr. Harry D. Tiemann, of Yale University, has prepared a clear statement of the elements of wood structure that affect this problem, which is published in full in Appendix C.

(c) Present practice:

A circular letter was sent to treating plants, railroad engineers and others likely to have had experience in grouping species of timber for treatment under practical conditions (see Appendix D), and these results have been abstracted for the report. It will be apparent that the net results of the canvass by circular letter are of service in showing the need for consideration of this problem and in describing the present practice.

(2) *Strength of Treated Timber.*

An examination of all available records of tests of treated timber, published and unpublished, has been made and the nature of the experiments and the conclusions abstracted. The abstract of the data will be published in a later Bulletin. In addition the Committee has arranged a series of tests which are being carried on at the present time (November 30, 1908).

Grouping of Species.

The various species, and, indeed, any one species, in its differing conditions of seasoning and habit of growth take treatment unequally when exposed to given retort conditions. For example, dry sapwood of the pines treats easily, but the heart is mainly impenetrable to creosote. Some dry red oak sticks take creosote in certain processes clear

through the heart, while beech under the same conditions is very refractory.

It is evident that if two woods like red oak and hickory, or loblolly pine and longleaf pine, or heart loblolly and sap loblolly, are placed in the same charge and the average absorption secured, one class will be over-treated and the other under-treated. Interests of economy and proper preservation demand that the various species should be segregated into different groups. This grouping would, no doubt, vary with the process used and geographical locality. The problem is conditioned by the possibility of separating the various species into proper groups under the conditions of a large commercial treating plant. Certain railroads, however, that receive many species of hardwoods for ties have specified the grouping.

It might seem at first that a suitable grouping could be predicated upon the known structural characteristics of the various species. The arrangement and means of communication between wood cells, the contents of these cells, the size and arrangement of pores and ducts are known and some of the laws of molecular physics controlling the movement of solutions are understood. The present known facts are, in the main, merely suggestive and not explanatory. However, the prosecution of inquiry of the science of preservation cannot but be aided by the kind of fundamental knowledge presented by Mr. Tiemann in Appendix C.

The various factors that enter into the problem may be listed as follows:

(a) Condition of timber with respect to seasoning.
(b) Proportion of heartwood or of sapwood.
(c) Characteristic micro-structure.
(d) Per cent. of summer wood and spring wood and position in trunk, if readily distinguishable.
(e) Geographical location of species, elevation, soil and other site conditions as affecting (a), (b) and (c), if ascertained.
(f) Mutual interaction between the various species when treated in the same cylinder.

It might seem that the experience of treating plants would furnish satisfactory empirical rules for grouping applicable to the treating process used. However, most plants have treated but few species and there seems to have been but little detailed and careful examination of the actual results of the cylinder process upon individual sticks. Conflicting reports are made as to the ease of treatment of a given species, as, for instance, ash and white pine. These are due in part to a confusion of species, or a difference of species grown under different site conditions or latitude. Some contradictions may be explained as mere opinion or prejudice unsupported by direct facts.

Some works are experimenting to determine the proper grouping

and the best conditions of treatment for each group, but the experiments are not yet sufficiently advanced for use.

The main results of the letter of inquiry given in Appendix D and the remarks are published, not because they serve to settle the inquiry, but because they are suggestive and exhibit the need for this study.

It appears in general that:

(1) In practice the Southern pines are separated on the basis of amount of sapwood.

(2) That green and seasoned timbers are treated separately.

(3) That Douglas fir requires separate and special treatment.

(4) That there is no well-authorized grouping of the various hardwoods, and that this should be a matter of further study.

Strength of Treated Timber.

As stated, the Committee has in progress a series of tests of treated timber which are not yet (November 30, 1908) complete, and the work presented at this time is a compilation of available reports on strength of treated timber.

(1) Tests on creosoted and untreated Douglas fir beams made by the Southern Pacific Creosoting Company at Sacramento, Cal., July, 1895, and May, 1906. Reported by William Hood, Chief Engineer. Report on results not in printed form; 94 sticks ranging in span from 2 ft. to 7 ft. and in depth from 2 in. to 16 in.

(2) Tests of creosoted, burnettized and untreated Douglas fir beams made at the University of California in April, 1898. Reported to the Committee by Prof. L. E. Hunt; not published completely. Tests include flexure, tension, compression parallel to the grain, compression perpendicular to the grain, and shear. There were 42 sticks tested. Beams varied from 1½ in. to 10 in. in depth and were tested on a 100-in. span. Care was taken to secure proper control tests on treated material. Necessary data recorded.

(3) Circular 39, Forest Service, "Experiments on the Strength of Treated Timber," W. K. Hatt, May, 1906. There were 6,272 tests, mainly on loblolly pine treated by the zinc-chloride and creosote processes at an experimental treating plant in connection with the St. Louis Exposition. The report includes description of the material and facts relating to the treatment of tests.

(4) Bulletin No. 18, University of Illinois Engineering Experiment Station, R. I. Webber, "Holding Power of Railroad Spikes." June, 1906. Spikes of various forms were driven into 44 ties representing 12 species. Ties taken from stock pile. History of ties and other data not recorded.

(5) Circular 46, Forest Service, "Holding Force of Railroad Spikes in Wooden Ties," W. K. Hatt, December, 1906. Study of the relative holding power of common and screw spikes in direct pull in loblolly pine ties seasoned, soaked and steamed.

(6) Tests made by C. F. Loweth, of the C., M. & St. P. Railway, in 1904. Not published. Fifty-six beams of natural and creo-

soted Southern pine; size ranging in depth from 3 to 10 in. and tested on spans 2 ft. to 13 ft. 6 in. Full history of treatment of material not recorded.

(7) Thesis by F. E. Osborne, School of Civil Engineering, Purdue University, 1901. "Effect of Preservatives on the Strength of Treated Timber;" 17 beams of natural and creosoted Wisconsin white pine were tested and accompanying tests made in compression parallel to the grain, compression perpendicular to the grain, and shear. Dimensions of specimens 4x4 in., tested on a 6-ft. span. Records of treatment available.

(8) Tests of creosoted Southern pine bridge stringers by the Forest Service at Purdue University, 1908. Results not published. Twenty Southern pine bridge stringers, 8x16 in., were cut in Southern Mississippi and treated 5 months after cutting at Grenada, Miss., by the straight creosoting process. The material included both longleaf and shortleaf. Tests were made 3 months after treatment in flexure, cross-compression, washer bearing, with accompanying minor tests. The full data of original treatment and tests of material are available.

(9) The tests of Douglas fir bridge stringers treated by the boiling process at Seattle, tested by Forest Service at University of Washington, Seattle. Results not published. Eighteen Douglas fir stringers were treated and tested as described in the case of the Southern pine at Purdue University.

(10) Tests on creosoted ties by Prof. A. N. Talbot, of the University of Illinois. No description has been obtained.

Experiments are under way at Purdue University for the Committee on Wood Preservation to determine the comparative resistance of railway ties, natural and treated, to the action of the rail. These include red oak ties treated by the Lowry process and also by the zinc-chloride process. A further series of tests is arranged for on bridge stringers treated by the Lowry process.

(D) TREATING PROCESSES.

The Committee in its investigations of particular processes and methods concluded that it could not at this time make definite reports on the proper execution of various forms of timber treatment. It is particularly desired at this time to make no changes in the specifications for treatment as given in the Manual. Further developments which are now in hand will result in a future report of treating specifications.

It was concluded to present general matter bringing out general principles observed in the application of wood preservatives. The discussion may be subdivided as follows:

Method of Application.

(1) Pressure process.

(a) Full cell.

(b) Empty or partly filled cell.

(2) Open tank process.

GENERAL PRINCIPLES TO BE OBSERVED IN APPLYING PRESERVATIVES.

Certain essentials must be observed to make the application of preservatives successful. First: The timber must be seasoned. It must be known to be of such character that it can be treated in the manner prescribed. Second: The element of heat is vital. Temperatures of the process must not be such as to be injurious to the wood. They must also be such that no change or injury will occur to the preservative itself. It is vital, however, that the temperature of treating be as high as possible, because this will either increase the fluidity of the preservative or tend to open the wood cells, or both. The maximum limiting temperature, however, is about 225 degrees F. It is essential in order to produce economical results in the cost of treatment that tanks, retorts or reservoirs, or whatever vessel in which the timber is treated, be provided with sufficient means of heating, so that the heating may be done quickly and may be easily and surely controlled. Third: In order that there may be minimum cost of application it is necessary to have proper velocity of treatment. This involves the entire design of the apparatus for the application. It must be possible to perform every step quickly and accurately, but at the same time thoroughly. Fourth: It must be possible to apply the preservatives uniformly to all pieces of timber in any one charge; that is, each particular piece must have its full quota; this, too, means that the timber in any one charge must be alike in character so far as its ability to absorb is concerned.

THE PRESSURE PROCESS.

The essentials of the apparatus of the process are, of course, the sealed retort and the pressure pump. The particular things which govern the apparatus are:

1. The character of the timber to be treated.
2. The character and amount of the preservatives used and the desired methods of application.
3. The desired capacity per day or per hour.

The pressure which must be maintained and the pressure which is the economical one depends on all the four essentials enumerated under the head of "general principles to be observed in applying preservatives." For refractory woods and heavy preservatives, as creosote, it must be possible to produce a pressure of 175 lbs. per square inch to obtain economic velocity of treatment. For light wood a pressure of 75 lbs. per square inch may be ample. These pressures, 175 lbs. per square inch and 75 lbs. per square inch, are in general the upper and lower limits used. If the timber to be treated is limited entirely to refractory woods as the red oaks, it must be possible to obtain the pressure of 175 lbs. per square inch. When only light woods, as sap pine, are used, a pressure of 75 lbs. per square inch may suffice, as stated.

The more fluid a preservative the more easily it can be injected and the lower will be the desirable pressures. High fluidity is valuable.

The higher the amount of preservative to be used per unit of timber, the greater will be the necessary pressure.

The desired capacity determines volumes and size of apparatus. A plant which will serve general requirements of the larger railroads will have a capacity of about 1,000 cubic feet of timber per hour. A plant of this capacity is one of moderately large capacity.

In the specifications for treatment adopted by the Association it is proposed to steam the ties unless they are thoroughly air seasoned, in which case it may be omitted, at the option of the purchaser. It is to be emphasized, however, that this scheme should at all times be omitted when the ties are thoroughly air seasoned and are to be treated with oils.

In applying preservatives to timber the particular result looked for is cheapness of application, and this application shall be such as to produce the full value of the preservative. There are in general two classes of preservatives used in the pressure process—oils and salts. In general the oils are injected as a whole, the salts being injected in solution. Economic treatment requires that with a given amount of preservatives in any particular piece there shall be a uniform distribution or a uniform depth of penetration from the surface. The extreme limit is complete saturation. With oils it has been impossible to obtain complete saturation in certain woods. In general, salts in solution may be distributed throughout any piece of timber with proper pressure and time. By means of moderate pressure, not exceeding 100 lbs. per sq. in., and in a period of time not exceeding one hour, light woods, such as dry sap pine, may be completely saturated. These woods absorb a practicable maximum of oil or solution. In laboratory experiments the maximum that can be applied is about 30 to 35 lbs. per cubic foot of timber. From this maximum there may be all ranges downward. There is another maximum of absorption for oils, creosote particularly, for the woods which cannot be saturated. Pressure is maintained until there is a complete refusal. This refusal takes place in certain species of oak when the penetration has proceeded a certain distance into the piece, ranging from 1 in. to 1½ in. in the center of the piece. In other timbers refusal takes place at the heart wood. The maximum absorption for these classes of timber ranges from 10 to 12 lbs. per cubic foot of timber. From this maximum, as in the case of the light woods, there are all ranges downward.

In the above the simplest pressure process is taken up. The wood cells which received preservatives are practically full of the fluid. This method of application may be named the full cell process. In order to reduce the amount of preservative used and still obtain maximum penetration, it is possible to remove from the timber a portion of the oil injected. The removal is part of the process of application. This method is applicable only when expensive preservatives, as creosote oil, are used. This process leaves the wood cells empty or partly so, and

in substance the walls of the cells are simply coated. The process may be called the empty, or partially filled cell process.

The maximum efficiency of the empty or partially filled cell process is obtained as in the case of the full cell process in light woods, sap pine, for example. As a maximum condition a piece of sap pine may be saturated and all the oil, except five or six pounds per cubic foot, removed. As stated before, the process of removal of oil is essentially a part of the process of application. The oil is removed immediately after saturation, which may be stopped at any particular point. In its simplest form the method consists in applying a vacuum of about 20 to 22 in. after the surplus oil has been removed from the sealed vessel or retort in which the oil was first applied under pressure. The vacuum is maintained until the proper bleeding or removal of oil has taken place.

It is to be emphasized that in the pressure process it is vital that the sealed vessel or retort must be provided with accurate measuring devices both for measuring volumes and temperatures. It must be possible to determine closely the actions within the retort.

OPEN TANK PROCESS.

The open tank process is the simplest form for applying a preservative. As its name indicates, it consists in dipping the wood in open tanks or vessels filled with the preservative to be used. It necessarily follows that this is an absorption, rather than an injection, of the preserving fluid. It also follows that the depth of penetration obtained is small, except for particularly open or porous woods, such as sap pine, where a penetration of 1½ in. has been obtained.

CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK.

The necessity for accurate records of results in American practice is urgent in order to furnish sound facts on which to base conclusions. It is found that the value of many experiments in the use of preserved timber has not been productive of knowledge to any proper extent, because of improper records. The Committee should go into this matter thoroughly and report on it next year. It should continue the gathering of statistics, co-operating with the Tie Committee and other committees in the gathering of statistics. This co-operation is necessary to avoid duplications. The Forest Service of the Government is doing considerable work on wood preservation and the Committee should make free use of this source of information. Statistics to be gathered in the future should be added on the report given in Table I, enlarging and extending it.

It has been found that coal-tar creosote and chloride of zinc will preserve timber when used under the proper conditions and when the proper quantity and quality of preservatives are used. The determination of the conditions should constitute a part of the Committee's work

together with work on other preservatives. Crude petroleum is at present being used to such an extent that work in this direction is warranted.

The necessity of work upon an improved rail fastening in connection with the use of treated ties is so urgent that the work should be assigned to either this Committee or some other proper committee for definite report. It is evident from present results that economic life of treated ties cannot be obtained without an improved rail fastening.

The Committee did not deem it necessary at this time to report in detail on destroying agents of wood. However, a report in this direction will at some time be necessary, particularly because by this means the action of preservatives themselves will be made clear.

The Committee should continue work in the determination of proper grouping of timber, working toward the end that some proper grouping may be determined upon. The preparation of the timber for treatment—seasoning, in other words—needs consideration. Some very serious questions in the deterioration of timber while undergoing seasoning now confront railroads which have adopted tie treatment. The proper handling of ties and timber prior to the injection of preservatives should have immediate attention. There is found to be no sound knowledge as yet on the effect of treatments on the strength of timber. As stated, the Committee has experiments under way which will be of value in determining this question. These experiments should without question be continued and if possible enlarged.

The Committee should next year report definitely on specifications for treatment by processes now in common use, making such changes as may be necessary, if any, in the specifications now published in the Manual.

To state the conclusions of this report in definite form they would be as follows:

(1) Coal-tar creosote and zinc chloride are efficient preservatives when properly applied and when used under proper conditions.

(2) It is necessary to keep better records than have been kept so far in order to form proper conclusions as to the merit of different methods and processes.

(3) Preserved wood may be destroyed by mechanical action long before it is decayed.

(4) The specification as given for coal-tar creosote is good practice and should be adopted.

(5) There should be a standard temperature at which coal-tar creosote is measured. The standard of 100 degrees Fahrenheit, as given in the report, is recommended.

(6) It is essential that timber should be properly grouped in order that a successful treatment may be obtained. The species, proportion of heartwood and sapwood, condition of the timber with

respect to its moisture content, and the wood structure, will in general determine this grouping.

(7) It is desirable to air-season timber in order to prepare it for treatment. Most woods can be best treated after being air-seasoned.

Respectfully submitted,

A. L. KUEHN, Engineer Track and Roadway, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, O., *Chairman.*

CARL G. CRAWFORD, Chief Bureau of Wood Preservation, Forest Service, Washington, D. C., *Vice-Chairman.*

R. N. BEGIEN, Division Engineer, Baltimore & Ohio Railroad, Philadelphia, Pa.

LINCOLN BUSH, Chief Engineer, Delaware, Lackawanna & Western Railroad, Hoboken, N. J.

T. E. CALVERT, Chief Engineer, Chicago, Burlington & Quincy Railway, Chicago, Ill.

O. CHANUTE, 61 Cedar Street, Chicago, Ill.

C. K. CONARD, Assistant Engineer, Erie Railroad, Middletown, N. Y.

W. H. COURTENAY, Chief Engineer, Louisville & Nashville Railroad, Louisville, Ky.

W. W. CURTIS, Caxton Building, Chicago, Ill.

E. B. CUSHING, Southern Pacific Company, Houston, Tex.

GEO. M. DAVIDSON, Chemist and Engineer of Tests, Chicago & Northwestern Railway, Chicago, Ill.

E. O. FAULKNER, Manager Tie and Timber Department, Atchison, Topeka & Santa Fe Railway, Topeka, Kan.

W. K. HATT, Professor Civil Engineering, Purdue University, Lafayette, Ind.

V. K. HENDRICKS, Assistant Engineer Maintenance of Way, St. Louis & San Francisco Railroad, St. Louis, Mo.

S. M. ROWE, Monadnock Block, Chicago, Ill.

EARL STIMSON, Chief Engineer Maintenance of Way, Baltimore & Ohio Southwestern Railroad, Cincinnati, O.

DR. HERMANN VON SCHRENK, Supervisor of Timber Preservation, Rock Island, Frisco and Chicago & Eastern Illinois Railways, St. Louis, Mo. *Committee.*

Appendix A.

EXPERIENCE ON THE LOUISVILLE & NASHVILLE RAILROAD WITH CREOSOTED PILES AND TIMBER.

Abstract from Letter from W. H. Courtenay, Chief Engineer.

In reply to the Committee's circular asking for information as to what year our road had experience in treating wood, the writer would say that creosoted wood has been in use on the Louisville & Nashville Railroad Company's lines since 1876. Creosoted timber was extensively used on the New Orleans, Mobile & Texas Railroad, extending from Mobile, Alabama, to New Orleans, Louisiana, many important structures having been built of creosoted timber from 1876 to 1879. The Louisville & Nashville Railroad Company acquired control of the road from Mobile to New Orleans in 1880. In 1882 large quantities of creosoted piles, stringers and caps were used in the construction of trestles and docks on the Louisville & Nashville lines in the city of Pensacola, Florida, and vicinity. The earlier use of creosoted piles was more particularly for the purpose of protecting them from attack of the sea worm, or teredo navalis. However, in more recent years large quantities of creosoted piles and sawed timber have been used on the Louisville & Nashville lines where not subject to attack from the sea worm, and have been used merely for economical reasons.

As to the second question, "what process or processes have been tested," the only process used on the Louisville & Nashville Railroad has been the creosoting process. For a time experiments were made with a combination of creosote oil and resin for treating piles. This combination was not considered satisfactory and the process was abandoned.

In reply to the third question, whether piles, timber, ties, etc., were treated, the Louisville & Nashville Railroad Company now has on its lines about 19,000 creosoted piles in trestles. It has about 30,000 creosoted piles in its docks and wharves. In addition thereto a considerable number of creosoted piles have been used for foundations for important buildings, and, in some instances, for foundations for bridge masonry where the piles would, at times, be dry. The same company has now about 13,000 linear feet of pile trestle, the deck of which is constructed of creosoted timber. The track on these trestles is ballasted, and it is believed that a creosoted timber trestle, carrying ballasted track, is an economical and durable structure. Creosoted ties have not been used to any great extent. However, on the road between New Orleans and Mobile, above referred to, about 15,000 ties were creosoted

at West Pascagoula, Miss., in 1877 and 1878, and placed during these years on various bridge structures on that line. No accurate record has been kept of those ties. About 30 per cent. of them were washed away by a hurricane during the year 1893, which destroyed large parts of the structures on which they were placed. Probably 45 per cent. to 55 per cent. were in service in 1896. About 600 of the creosoted ties which were placed in 1877-1878 remained in the track until June, 1905. On one trestle 400 creosoted ties were placed in 1876, which ties were removed in 1903.

As to species of wood chiefly treated and approximate quantities, the only species of wood treated are longleaf yellow pine and loblolly pine; probably three-fourths of the total quantity having been the former.

For the timber treated in 1876, 1877 and 1878, about 16 lbs. of creosote oil per cubic foot of timber were used. Records are not now available to show, with any precision, the number of pounds of oil per cubic foot used since that time. However, the general practice has been to use from 20 to 22 lbs. of creosote oil per cubic foot of timber for piles to be placed in salt water, exposed to the teredo navalis, and about 16 to 18 lbs. per cubic foot for piles not exposed to salt water. About 12 lbs. per cubic foot is used for sawed timber for trestles.

Regarding our estimate of the resulting life, from our experience with creosoted timber we assume, for the purpose of making comparative estimates of cost of various kinds of structures, a life of 25 years for creosoted timber in ordinary trestles. On the line between Mobile and New Orleans there are creosoted yellow pine stringers on certain trestles which were placed there in the year 1878 and which are still sound. These stringers were protected to a large extent from exposure to the sun by a covering of sand upon which the ties were laid. On the Pensacola and Atlantic Division there is a trestle across Escambia Bay 10,892 feet in length. This trestle was constructed in 1882 of creosoted yellow pine piles, and with creosoted deck timbers. The deck of this trestle was destroyed by a hurricane in September, 1906, the entire deck having been washed away, carrying with it the rails and the caps of the bents. A very considerable portion of material from this deck was recovered from a point about five miles above the site of the trestle. The creosoted stringers were nearly invariably found to be good, and nearly all of the stringers which were recovered have been used elsewhere in making ordinary trestle repairs.

As to known failures to show economical results and why, I cannot say that I have known of failures to obtain economical results with timber properly treated. Instances have come to my attention of timber having been burned by the seasoning process. The experience of our people has been that where decay is found in creosoted timber, it is invariably found around bolt holes which were bored after the timber was treated, or at other places in the timber where the creosoted wood was cut through, exposing the green wood beneath. It is important,

therefore, so far as practicable, to have all framing done before the timber is creosoted, and where necessary to bore bolt holes, or otherwise cut creosoted timber, the bright wood exposed should be painted or otherwise covered with hot creosote oil.

It is very important that thoroughly honest work be done in creosoting timber. The process is one in which it is extremely easy to do bad work without the fact being known to the inspector unless he is thoroughly expert. A fruitful source of trouble is an undue quantity of water becoming mixed with the creosote oil by leaky steam pipes or otherwise. The utmost care should be taken both to secure the proper quality of oil and proper treatment. Particular care should be exercised to see that undue quantity of water does not become mixed with the oil.

Referring now to the value of the creosoting process as a protection against the teredo navalis, or limnoria. Our experience with this is very variable. In 1887 the writer inspected, as carefully as could be done without a diver, about 6,000 piles driven in salt water at Pensacola, Fla., and vicinity. These piles had been driven in 1882. A very heavy percentage of them had been attacked by the teredo navalis, but only two were damaged to such an extent as to necessitate their removal. Similar inspections have been made systematically by others later, and since about 1890 these inspections have been made by divers as well as superficial inspections near the water line. Nearly the whole number of these piles are still in use, although it has been found necessary to protect a considerable quantity of them by casings of cement or vitrified clay pipe. In 1890 the writer had inspections made of creosoted piles which were driven in 1878 in water infested with teredo navalis, piles having been driven in water of depths varying from 10 to about 50 feet. Very careful inspection was made, and when the diver reported a pile badly eaten by the teredo he was required to bring to the surface a sample of the eaten wood. A very small percentage of damage was found. That pile which was reported to have been most cut by the teredo was pulled out, with considerable difficulty, and was found to have had less than one-third of the cross-section of the pile, at the worst place, destroyed. Nearly all of these piles are still in place and giving service. It is desirable, however, where piles are driven in water infested with teredo that frequent inspections be made. Our experience leads me to believe that creosoted timber, not subject to action of seaworm, but for ordinary use, will last far longer if not exposed to the action of the sun than if so exposed. The sun seems to have the effect of drawing the creosote oil to the surface. I have seen frequent instances where the ground at the foot of a pile was covered for a radius of a foot or more from the pile with a coating of creosote oil. Experience on the Louisville & Nashville lines leads me to believe that properly creosoted timber, protected from the sun, will be sound for thirty years after it is placed. A careful examination was made in 1904 of some 3,000 piles, which were driven in salt water in 1882, in order to determine to what extent the piles had de-

cayed in the heart, or in that part of the wood not impregnated with creosote oil, and not submerged in water; the examination was made by sounding the piles under the caps, and where any indication of unsound wood was found, borings were made with a small auger. It was found that only about 3 per cent. of the piles examined showed any indication of heart rot. The outer, or creosoted, wood of these piles remained sound. Doubtless this decay was due to the fact that the piles were of larger diameter than width of the cap, and necessarily, having to be cut, they exposed the portion of the wood not impregnated with creosoted oil; although these exposed parts were painted with hot creosoted oil and covered with pitch, it is probable that decay was due to the exposure of untreated parts of the wood.

In response to the Committee's request for such additional information as is obtainable with reference to average life of cross-ties on the Louisville & Nashville lines, I attach a statement entitled "Record of Creosoted Bridge Ties Treated and Placed in Service in 1877-78 on the New Orleans and Mobile Division of the Louisville & Nashville Railroad," compiled by John B. Lindsey, Superintendent of the West Pascagoula Creosoting Works. The information given in this statement cannot be accepted as certainly correct, for a part of the information is obtained from recollection of the Bridge Supervisors, who were in immediate charge of the structure on the New Orleans and Mobile Division, and not taken from carefully preserved written records.

"About 15,000 ties were creosoted for the Louisville & Nashville Railroad at West Pascagoula in 1877-78, and placed during those years in various bridges on the New Orleans and Mobile Division. Unfortunately no record has been kept of these treated ties. About 30 per cent. were washed away by the storm of 1893, but probably 45 to 55 per cent. were in service in 1896, giving a life service of 19 years.

"Although this data is entirely insufficient for definite conclusions, it seems probable that this lot of creosoted bridge ties would have given an average life service of at least twenty years, leaving storm losses out of consideration.

"The record of 1893 creosoted bridge ties on Bridge No. 18 in Biloxi Bay is a remarkable one, over 28 per cent. of the ties originally placed on the bridge giving a life service of over 27 years. Many of these creosoted ties have been turned on side and used. No tie plates were used on these ties, and the failure of ties was generally due to rail cutting and spike holes, and not to decay of the wood."

In 1887, in passing over some of the structures mentioned in the foregoing statement, the writer made an examination of cross-ties and other creosoted timber, and attention was called to the fact that the fiber of splinters torn off from a number of the cross-ties seemed to be dead. These splinters could be crushed in the hand without danger of injury to the hand. It developed that the cross-ties used had been accumulated long in advance of the time they were creosoted; had been lying on the ground, and many of them had rotted to considerable

extent before they were creosoted. A number of the ties checked badly in the sun. It was the custom about twenty years ago to fill these checks with hot pitch, and then cover the pitch with lime so as to harden it. Considerable trouble was experienced by trains igniting the pitch when passing over the structures, so, later, the expedient of filling the space between ties with plank and then covering the ties and plank with sand, and later with blast furnace slag, was adopted, mainly as a preventive measure against fire. The writer has now in his office a sample of the worst decayed creosoted stringer which could be found in Bay St. Louis trestle during an extensive inspection and overhauling of this structure during the present calendar year. The top of this stringer is badly decayed, but it still has a great deal of sound wood. We have another sample which our Bridge Supervisor sent us to represent the average condition of all the creosoted stringers in this structure. These stringers were placed thirty years ago.

Appendix B.

PRECAUTIONS TO BE OBSERVED IN BURNETTIZING TIES.

Suggested by Octave Chanute.

(1) Wood should be well seasoned. The best check on this is the weight per cubic foot previously ascertained for a particular species of wood which takes the treatment well. Some resinous woods, such as Oregon fir, may best be treated when the sap is yet liquid.

(2) Different species of wood or woods taking treatment in different degrees should not be mixed in the same charge. Otherwise irregular injection will result.

(3) If the ties are sawed, lath or iron strap should be put between the layers to give the solution easy access.

(4) When the wood is thoroughly seasoned steaming may be dispensed with and better results obtained.

(5) Steaming, when necessary, should never exceed 20 pounds to the square inch pressure, to avoid injuring the fiber. It should be continued from one to three hours, as dictated by the state of seasoning and experience.

(6) Vacuum, when applied prior to injection of preservative, should be 20 to 26 inches for 1 to 2 hours. It is desirable to measure the amount of sap extracted.

(7) The pressure on the solution, previously heated to 150° Fahrenheit, may be varied with the species of wood and continue from 1 to 3 hours as found best. It should not exceed 200 lbs. per sq. in.

(8) The strength of the solution, made from chemicals previously tested for purity, should be such as to inject an average of one-half pound of dry chloride of zinc to the cubic foot. The strength of the solution should be tested for each run.

(9) The amount of solution absorbed is preferably ascertained by weighing each buggy load, both before and after treatment.

(10) Treated ties should dry in close piles, in ordinary weather, for 20 to 30 days before being put in track, to insure the best results.

(11) Daily statements should be made of each run and be submitted to the proper authorities.

(12) Accurate records should be kept of the life of the ties in the track for at least ten years. For this purpose dating nails should be used, and their shape may be varied to distinguish special modes of treatment, etc. It is possible to obtain a result of the life of the ties by placing them in an experimental section of track.

Appendix C.

THE MICROSCOPICAL STRUCTURE AND PHYSICAL CONDITION OF WOOD AS AFFECTS PENETRATION BY PRESERVATIVES.

BY HARRY D. TIEMANN, Yale Forest School.

In the following paper the aim will be to point out certain peculiarities in the microscopical structure of wood, with reference to their probable influence in regard to penetrability by fluids. Much study and laboratory experimentation is necessary before any definite predictions can be made as to the behavior of any particular species in the treating retort, and just what physical laws come into play; but if this brief exposition of facts will help to establish the value of a thorough scientific study of the subject of the treatment of wood from the anatomical and physiological standpoint, a definite object will be accomplished.

Wood, as is well known, is an exceedingly complex structure, both physically and chemically. Almost the entire substance is of organic nature, and cannot be produced artificially. Before discussing the wood-substance, however, it will be best to examine its physical structure.

Imagine a honeycomb, greatly extended in the longitudinal direction of its little tubular cavities or cells by the addition of successive cells one above the other, but each cell completely closed by its own waxy wall, which is fused to the wall of the neighboring cells. The idea will be of assistance in a comprehension of the descriptions which follow, but must not be taken as an accurate model of a piece of wood.

Wood is composed of series of closed "cells" arranged as in the honeycomb, but instead of being approximately all of the same size, their sizes and shapes vary greatly, sometimes in the same piece.

There are also in all woods, besides the vertical columns of cells, horizontal rows occurring at short intervals between the vertical columns and closely fitted in between them. These horizontal rows are in narrow vertical plates from a few thousandths of an inch to an inch or more in height, arranged radially in the trunk of the tree, and generally continuing for considerable distance, often the entire distance from the bark to the center.

The vertical columns are arranged more or less in concentric rings about the center of the tree. Each year a series of these rings is formed between the bark and the wood of the last year; the first rings are of very thin-walled cells, but in each successive ring the walls become

thicker and thicker, until at the end of the season only very heavy thick-walled cells are formed.

The spaces within the cells, called the *lumena,* in consequence become smaller and smaller as the walls grow thicker, until sometimes they nearly disappear.

The next spring, when growth begins, a layer of thin-walled cells is laid on directly next to the last row of heavy walled cells. This abrupt change is clearly visible to the naked eye and marks the limits of the "annual rings." These annual rings are what give the appearance of "grain" to the wood, and the horizontal rows of cells or "medullary" rays, as they are called, are commonly seen as the "silver grain" in oak, maple, beech, etc. The only reason that the silver grain is not seen in ash or pine is because the medullary rays are too small in these species to be noticeable.

The structure of wood has been shown in many publications, but for a brief description and some excellent photo-micrographs the reader is referred to Dr. Hermann Von Schrenk's Bulletin on "The Decay of Timber," 1902, Bureau of Plant Industry, United States Department of Agriculture.

Further description here would seem redundant but for the necessity of having the material clearly before the reader while discussing the features in particular. The writer will therefore take time to discuss the structure more in detail.

There are two distinct classes of wood as to structure, the conifers or "soft woods," and the broad-leaved trees or "hard woods." The wood of the conifers is composed almost entirely of one kind of cells, except for the medullary rays, while that of the broad-leaved trees is composed of at least two and often five or six different kinds of cells. We will therefore take up first the wood of the conifers.

The cells of these are known as "tracheids" and are considerably longer than wide, with more or less oblique ends. The walls of these cells are composed first of a very thin membrane completely enclosing each cell, known as the *primary wall,* and upon this wall is deposited a *secondary wall* or thickening layer, which is very much thicker toward the end of each annual ring. This is shown in Figs. 1 and 2, which are cross-sections of Longleaf Pine, Fig. 2 being more highly magnified than Fig. 1. Fig. 2 shows the end of one annual ring with the thick walls and the beginning of the next ring with the thin walls.

This secondary wall is not complete, but is perforated on the ends of the cell and on its two radial walls by a great many small round orifices, which correspond exactly in position with similar orifices in the walls of the adjacent cells. Thus the two orifices coming together form a lenticel-shaped orifice in the walls between the *lumena* of the adjacent cells.

This orifice, however, is *not open,* but is *closed* through the center by the membrane of the primary walls. Fig. 3-A. These *"bordered*

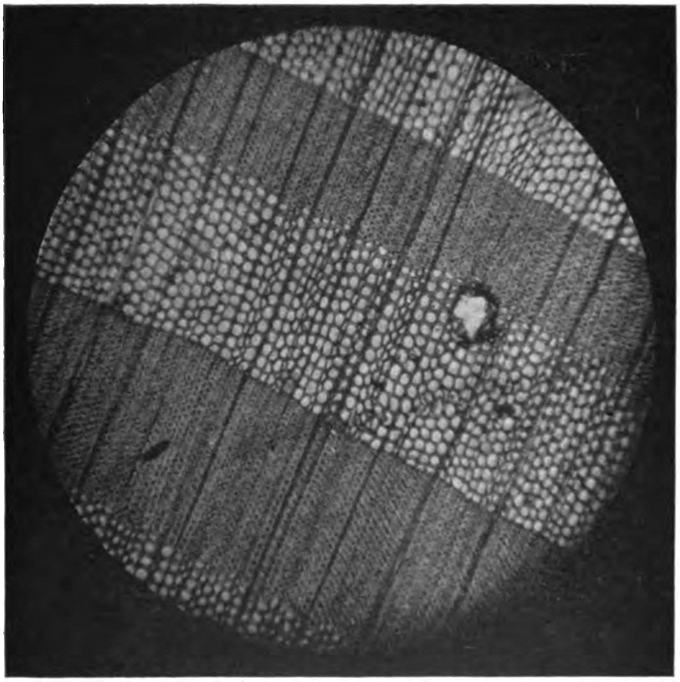


FIG. 1—CROSS-SECTION OF A PIECE OF LONGLEAF PINE.

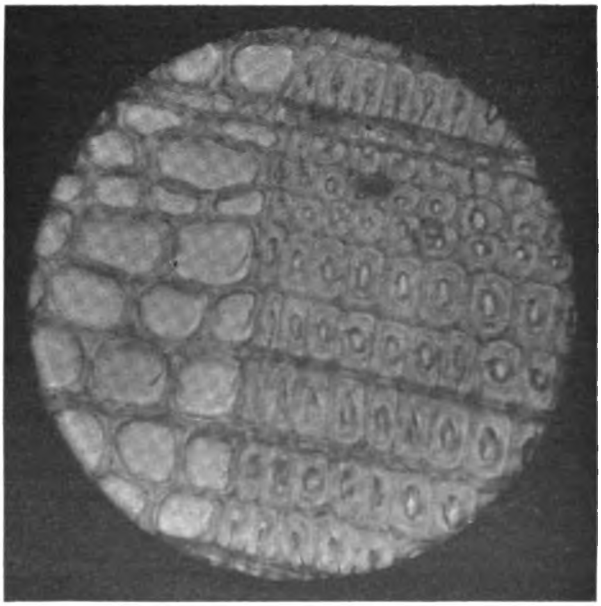


FIG. 2.—CROSS-SECTION OF A PIECE OF LONGLEAF PINE, HIGHLY MAGNIFIED.

pits," as they are called, are so numerous in the walls of the tracheids as to form a feature as important as the walls themselves. They are so numerous as to appear in the longitudinal sections as chains of rings. Fig. 3-C.

The partition membrane, called the "middle lamella," usually has a thickening disc in the middle, as in Fig. 3, called the *torus.*

The primary wall of the cell, including the middle lamella, is remarkably permeable to water, but almost completely impermeable to air when wet. The torus, however, is thought to be composed of a different substance, which is only slightly permeable to water.

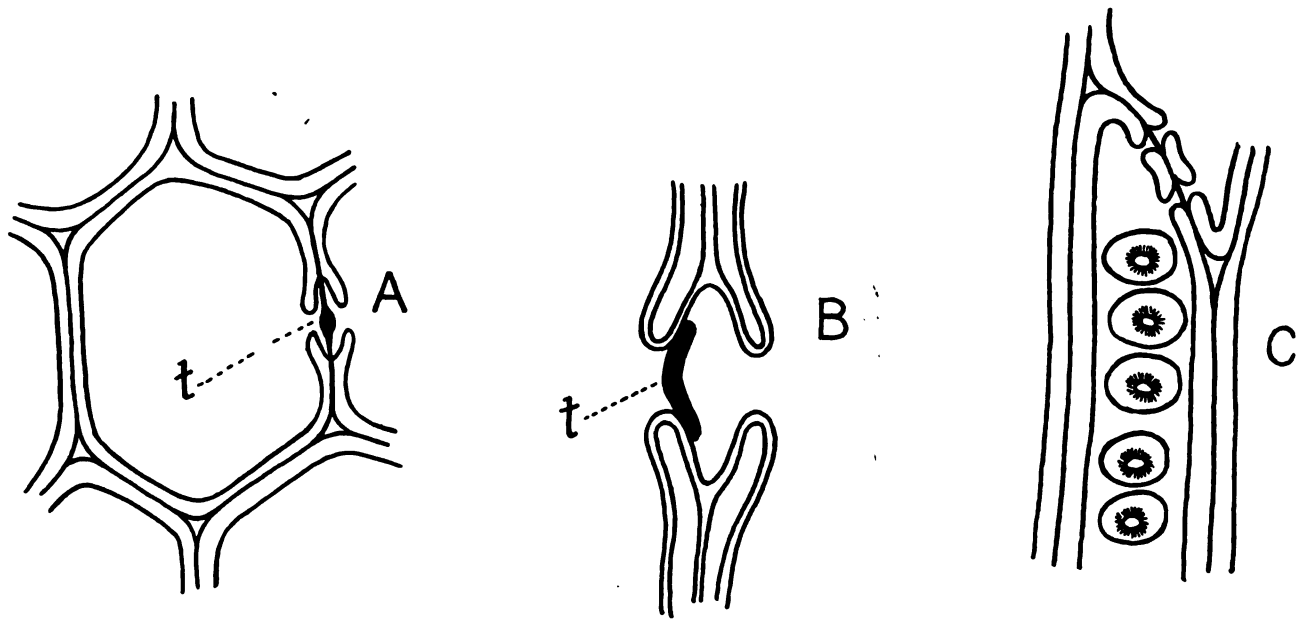
As the membrane is elastic, this arrangement of torus and lamella forms a remarkable mechanical valve which completely closes the orifice of the pit when the pressure within the cell becomes sufficient to press the torus against the enclosing ring, as in Fig. 3-B. It thus acts like a pump valve, but closes to excessive pressure in either direction.

Let us suppose the lumen to be full of water under a slight pressure, but which is not sufficient to close the valve. Water will then be forced through the membrane, something like a filter, but as the pressure increases until the opening is completely closed, the flow of water will be very much reduced or entirely stopped. It must be remarked in this connection that the entire cell wall is peculiarly permeable to water, but as the walls become very much thickened, they must offer great resistance to the passage of water, whereas the membrane of the pits allows it to pass through with great freedom. These bordered pits persist even in the thickest walled cells.

These tracheids occur in the woody tissues of all plants and all species of woods, and they are the *only* kind of element which is never missing, aside from the small parenchyma cells which contain the living protoplasm, and of which the medullary rays are chiefly composed. There is now no question but that these tracheid cells have to do chiefly with the conduction of water through the stem of the living plant. Just how this is accomplished has so far completely baffled all investigation, although it has long been a topic of discussion among scientists. That the water rises to the tops of the tallest trees, as much as five hundred feet in some cases, is a self-evident fact, and that it passes through the tracheids has been well established, but no completely satisfactory explanation has been given.

This subject of the transpiration of water through woody tissues has a very direct bearing upon the impregnation of wood with preservatives. If we knew more about the conditions which control the movement of water we would know more about the methods of operation in the wood treating cylinder.

In the living trees water rises through the outer layers of wood, called "sapwood," and very little and probably none at all rises through the heartwood. In such species as beech, however, which are all sapwood, water continues to pass through the entire stem, though probably most freely through the outer layers.



CROSS-SECTION OF A TRACHEID, SHOWING BORDERED PIT IN THE WALL, WITH MIDDLE LAMELLA AND TORUS *t*. SAPWOOD.

FIG. 3—ENLARGED SECTION THROUGH A BORDERED PIT OF A TRACHEID IN HEARTWOOD, SHOWING CLOSURE OF ORIFICE BY THE TORUS *t*.

RADIAL SECTION THROUGH A TRACHEID, SHOWING NUMEROUS BORDERED PITS.

In the sapwood of living trees the torus of the bordered pits lies in its normal position as shown in Fig. 3-A. As the sapwood changes to heartwood, however, the torus is pressed against the opening, as in B, and becomes firmly cemented or united to the rim. It is probably *sucked* into this position by the partial vacuum formed in the neighboring cell, as its water content transfers out through the wall, since the cell, as stated before, is quite impervious to air. Gradually the lumena of the heartwood lose most of their free water and air very slowly takes its place. The walls of the cells, however, remain saturated.

The tracheids with these peculiar valve-like pits are apparently capable of withstanding an enormous pressure. In the living cells the pressures due to osmosis frequently amount to three or four atmospheres, and it is stated by Strassburger that a pressure as high as eight atmospheres (120 lbs. gage) have been measured. Livingston states that the pressure may vary from two to more than a hundred atmospheres (1,500 lbs. gage) within living cells.*

In addition to the tracheids, many of the conifers, particularly the pines, contain *"resin ducts,"* which are tubular passages of much greater diameter than the tracheids, scattered here and there at irregular intervals. They are not sufficiently numerous to form a structural feature of the cross-section of the wood, however. One of these ducts is plainly visible in Fig. 1, which is a section of longleaf pine, and two are visible in Fig. 4, which is a section of loblolly pine sapwood enlarged exactly the same number of times. A more highly magnified view of such a duct is shown in Fig. 5. As the name implies, these ducts are more or less filled with resin, which also permeates all the

*Mr. Tiemann writes separately the following: "It seems exceedingly doubtful whether liquids are ever really forced into the cells or 'sucked' out of them by mechanical pressures, at least in green wood. It is possible that when the wood dries the cells may in some instances check open and allow free passage, but this is purely speculative and requires demonstration. This whole question requires further investigation. It should be noted here that the liquids without doubt are pressed through the resin ducts and the 'vessels' of the heartwoods, as through tubes, but these will be described shortly. Some other explanation appears to be necessary for the penetration of the solutions into the lumena of the cells. Do they seep through the cell walls and the lamella of the ducts as does the water? The writer has made some experiments in attempting to force air and steam through woods under pressure. As a rule, with the conifers it has been impossible to obtain any penetration through a length of less than three inches, even at 130 lbs. pressure. Some penetration to steam was obtained in loblolly pine sapwood, but the writer believes that this was largely through the resin ducts. The hardwoods, containing vessels, such as Red Oak, Chestnut, Ash, Hickory, etc., were all permeable to a more or less extent, doubtless through the vessels, but White Oak, for a reason which will appear, resisted all effort. The writer has also examined small splinters of creosoted Longleaf Pine under the microscope while applying an air pressure of 20 lbs. to one end, the other end at a distance of two or three inches from the pressure end being free. Although the tracheids were nearly filled with the liquid creosote, no significant movement of the liquid was observed."

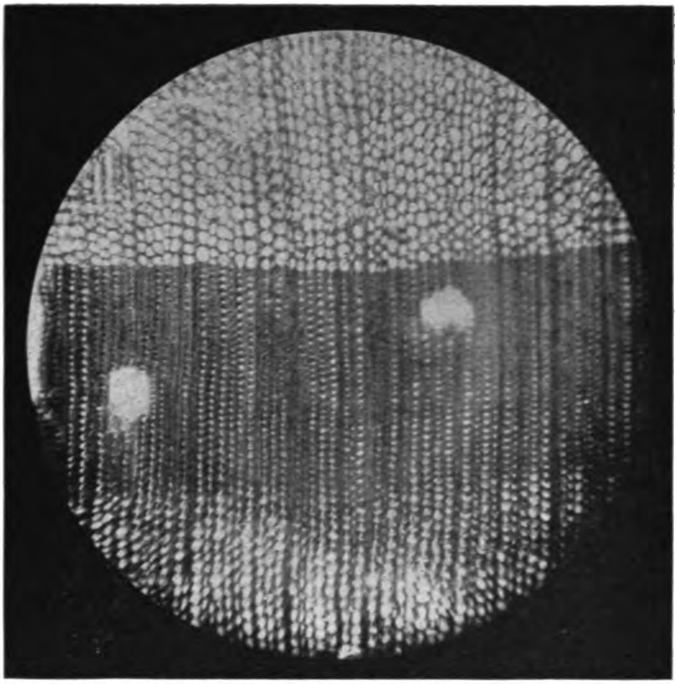


FIG. 4—CROSS-SECTION OF A PIECE OF LOBLOLLY PINE SAP WOOD.

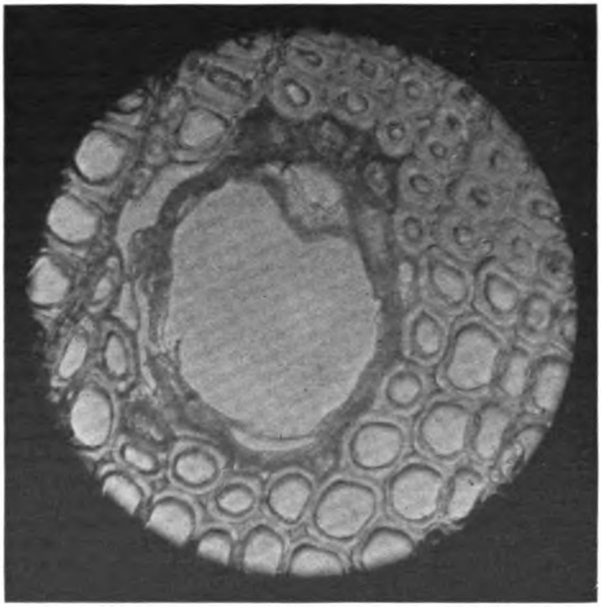


FIG. 5—RESIN DUCT IN A PIECE OF LONGLEAF PINE; CROSS-SECTION HIGHLY MAGNIFIED.

wood tissues. In Figs. 2 and 5 some of the bordered pits, as in Fig. 3-A, are visible in the photographs, but they may be obscured in the reproduction. In other species of the conifers, as the Douglas Fir, the continuity of the resin tubes is somewhat interrupted by constrictions, and in sequoia, fir and hemlock they are reduced to simple, small cavities called cysts.

The *medullary rays* are composed of short thin-walled cells having "simple" pits in the walls. These pits are of various forms and shapes, according to the species of wood, but do not have the peculiar valve-like structure of the bordered pits of the tracheids. They are closed, as in the latter, by the membrane of the primary wall. These cells when living contain protoplasm and the various foods and products of vital action. They serve a totally different purpose from the tracheids and form a vital link between all the living elements of the plant.

These cells with living contents, which occur also about the resin ducts in the conifers, and more or less throughout the woody tissue of the hardwoods, are called *parenchyma* cells. The medullary rays of most of the conifers contain in addition to the parenchyma cells, one or more rows of tracheids, but of a peculiar, flattened form, with smaller bordered pits. The pines have also resin ducts in the medullary

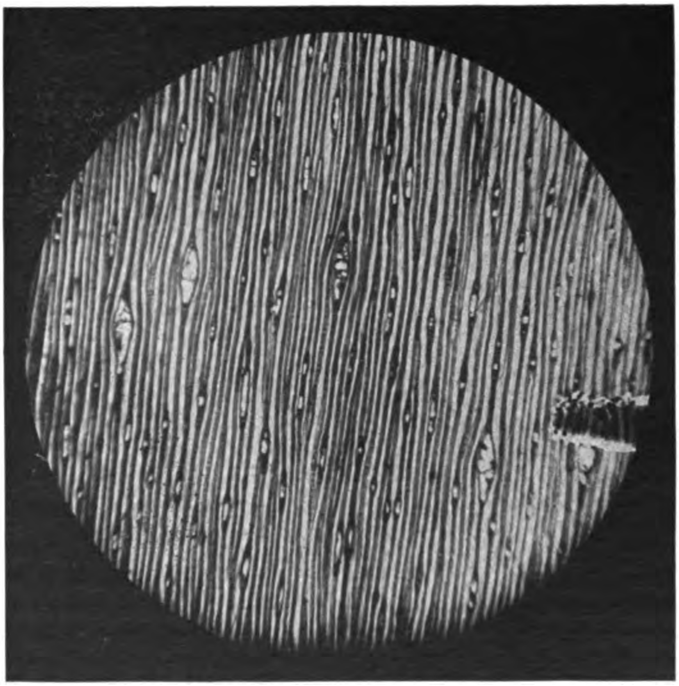


FIG. 6—TANGENTIAL SECTION OF A PIECE OF LONGLEAF PINE

rays. These resin ducts are visible in the tangential section of longleaf pine shown in Fig 6. Time prohibits further discussion of the conifers, and we will now give brief consideration to the more complex and diverse structure of the broad-leaved species or hardwoods.

The simplest of these contain, in addition to the tracheids, certain long, tapering, thick-walled cells called wood-fibers. Taking the red gum as one of the simplest type, the three elements are shown in Fig. 7, which have been drawn to scale directly from the microscope. An enlarged view of the parts is shown in Fig. 8. The tracheids in this case are very large and resemble the vessels of other species. They are joined or spliced end to end by a slanting wall containing pits much

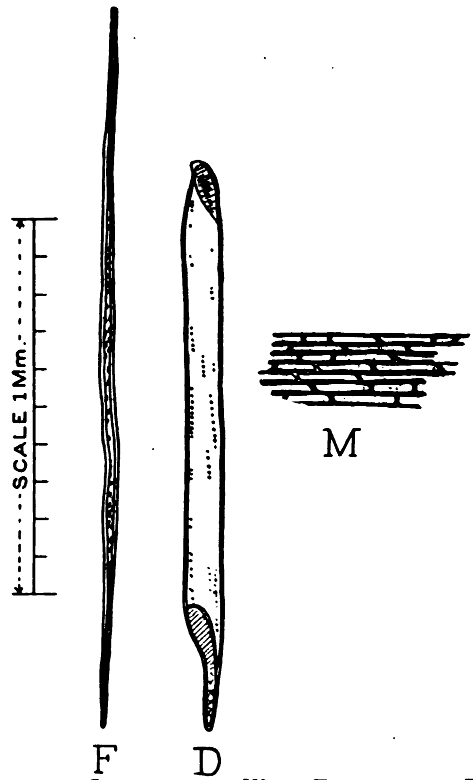


FIG. 7.—COMPARATIVE SIZES OF THE WOOD ELEMENTS OF RED GUM. F, WOOD FIBER; D, DUCT OR VESSEL (TRACHEA); M, MEDULLARY RAY CELLS.

resembling a grating. They also have bordered pits on their side walls. The fibers, Fig. 8 and Fig. 9, constitute the main body of the wood, and contain small, slit-like pits. These are visible in the cross-sectional view shown in Fig. 9. Figs. 7, 8 and 9 are taken from Bulletin 58, Bureau of Forestry, on "The Red Gum," and were drawn from the microscope by the writer. A brief description of the structure of this wood is given in the bulletin referred to.

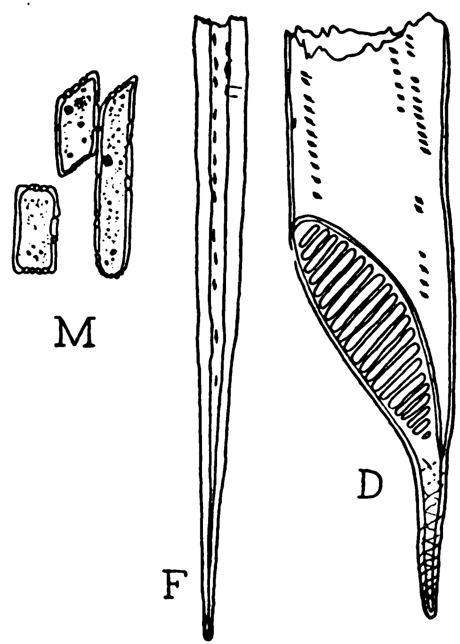


FIG. 8—HIGHLY MAGNIFIED PORTIONS OF THE ELEMENTS OF RED GUM WOOD. D, END OF A DUCT OR VESSEL (TRACHEA), SHOWING THE PECULIAR GRATING; F, POINTED END OF A FIBER; M, SHORT MEDULLARY RAY CELLS. THE NARROW SLIT-LIKE PITS ARE SEEN IN THE WALLS OF EACH ELEMENT.

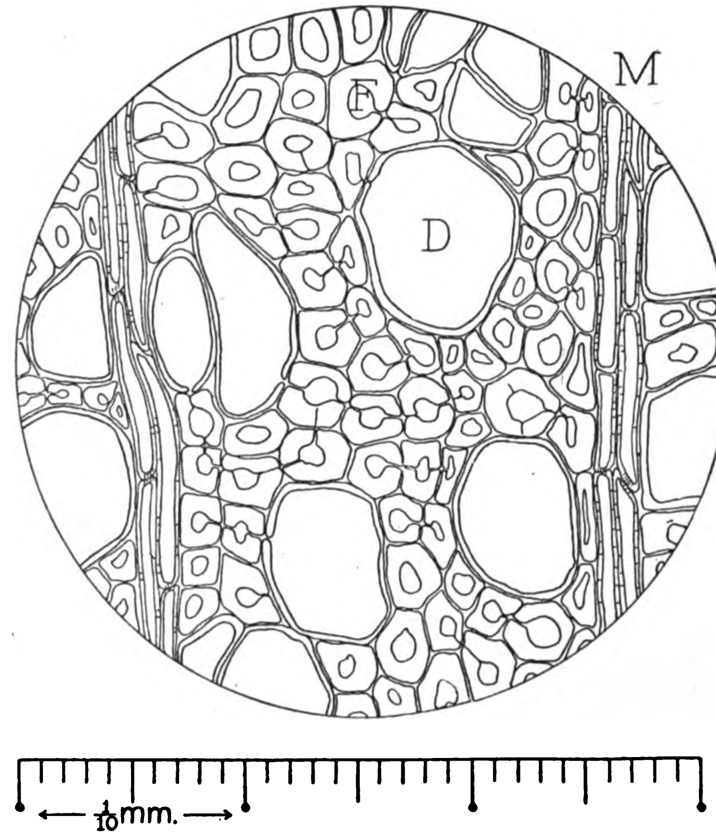


FIG. 9—CROSS-SECTION OF RED GUM WOOD, SHOWING THE STRUCTURE. F, WOOD FIBER; D, DUCT OR VESSEL (TRACHEA): M, MEDULLARY RAY CELLS.

Many hardwoods, such as the oak, contain, besides these wood-fibers and tracheids, much larger tubular cells, the end walls of which often break down, thus forming continuous tubes or pipes running more or less the entire length of the stem. These are so large in the oaks as to be very noticeable to the naked eye, and they constitute what are commonly referred to as the "pores" of the wood.

These vessels are plainly seen in Fig. 10, which is a cross-section of a piece of red oak at the junction of two annual rings. The large vessels are in the early spring wood, and the smaller ones are in the dense autumn wood of the previous year. The edges of the medullary rays appear as dark parallel lines, one very wide one being shown. The small pin-like holes are the tracheids and the minute points the wood-fibers and parenchyma cells.

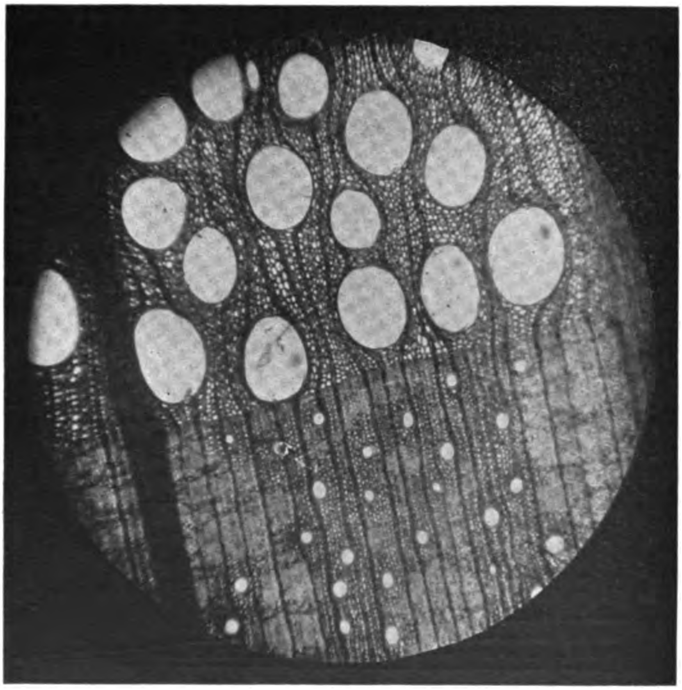


FIG. 10—CROSS-SECTION OF RED OAK AT JUNCTION OF ANNUAL RINGS.

But not only are there the four distinct classes of cells present, namely, wood-fibers, tracheids, vessels, and parenchyma cells, but there are all gradations and combinations of these cells. Some have spiral thickenings of the walls, and some have ladder-like thickenings. A longitudinal section through these large vessels, tangential to the radius

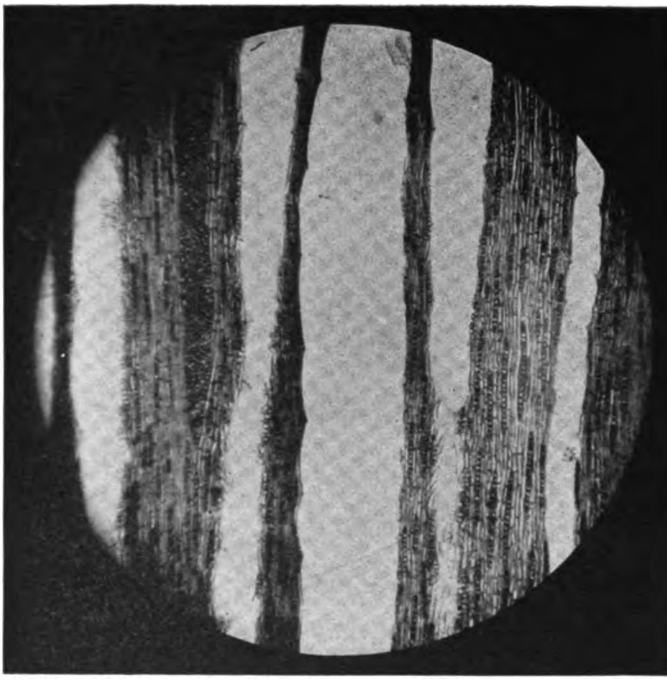


FIG. 11—TANGENTIAL SECTION OF RED OAK THROUGH THE LARGE VESSELS.

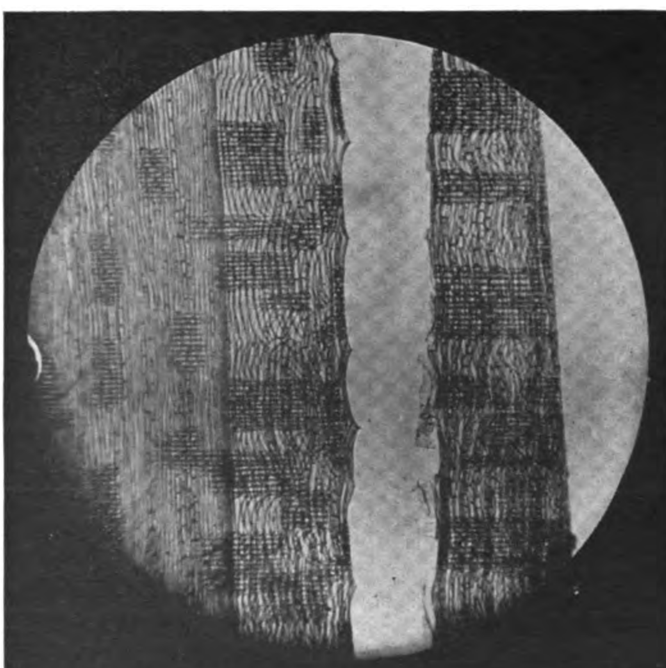


FIG. 12—RADIAL SECTION OF RED OAK THROUGH A SINGLE VESSEL AND AT JUNCTION OF ANNUAL RINGS.

of the tree is shown in Fig. 11, and Fig. 12 is a radial section through one vessel, taken at the junction of the autumn and following spring wood. It shows clearly where the original partitions across the vessel existed.

Now one can readily understand how liquids can be forced by pressure directly through these ducts or vessels. In fact, one can readily with the mouth blow air through a stick of red oak several feet long. But how can the liquid be made to pass into the lumena of the cells which are completely closed by the primary walls?

Fig. 13 shows a cross-section through a piece of white oak to exactly the same scale as Fig. 10. It will be seen that the vessels are nearly, if not quite, as large as those of the red oak. Yet it was found impossible, as stated before, to force air or steam through a piece of white oak less than 3 inches long and under a pressure of 130 lbs. Why this difference?

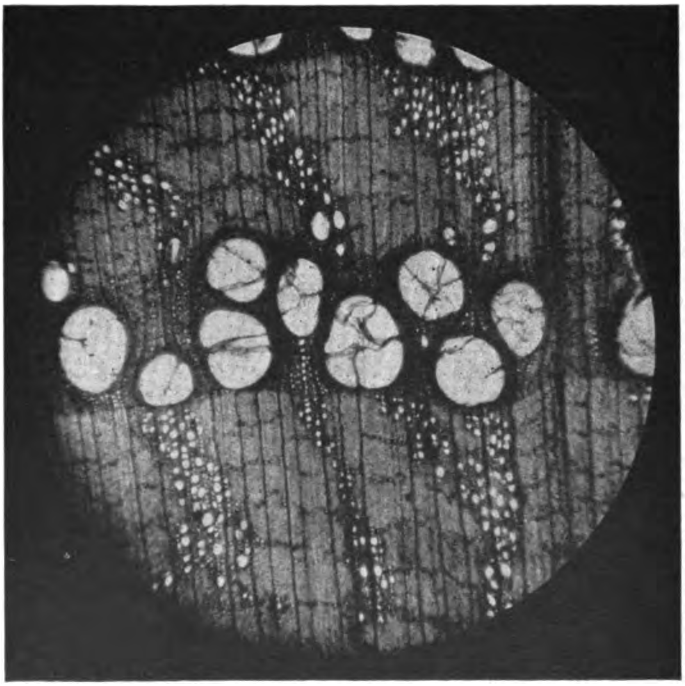


FIG. 13—CROSS-SECTION OF A PIECE OF WHITE OAK, SHOWING TYLOSES IN THE VESSELS.

Examination of the vessels in Fig. 13 will disclose a peculiar formation within them. These are ingrowths, called tyloses, composed of

Fig. 14—Tangential Section of White Oak Through the Large Vessels, Showing the Tyloses.

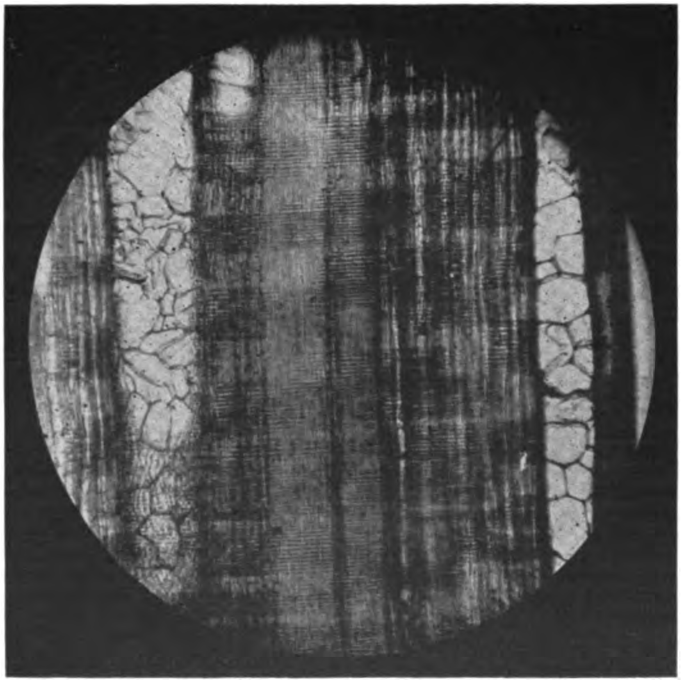


Fig. 15—Radial Section of White Oak.

very thin-walled cells, which gradually grow into the pores and lumena of the cells as the change from sap to heart wood takes place, and effectually seal the spaces to the passage of air. These are well shown in the tangential section, Fig. 14, and by comparing this with the similar section of red oak, Fig. 11, the cause of the resistance to penetration is very strikingly apparent. Fig. 15 is a radial section of white oak similar to Fig. 12 for red oak.

The majority of the hardwoods, and even some conifers, have these tyloses to a greater or less extent. In the case of the white oak the futility of supposing that liquids could be forced through these passages by pressure is self-evident, from a study of the structure.

Before closing, the writer would make a brief remark upon the substance of the cell walls. The primary wall is composed of a carbohydrate known as cellulose and having the same chemical formula as starch. It is of remarkable structure and absorbs moisture from the air or gives it up again in proportion to the vapor tension of the surrounding space. It swells and shrinks in proportion to the amount of water which it absorbs. In contact with water, under given conditions, it will absorb a definite amount and no more. It is also permeable to a great many solutes, as various salts, sugars, etc. To what degree it is permeable to oils such as creosote the writer is unable at present to state. The secondary wall is composed of a very complex substance called by the general name of lignin, which has never yet been satisfactorily analyzed. This also has the properties described for the primary wall, but probably to a much less degree.

When wet the primary wall, as before stated, is practically impervious to air, but it allows the transmission of water with the greatest of ease. Evidently here we have an explanation of the action of wood to the penetration of solutes. Any permeable solute will readily soak through the cell wall into the cell lumena, provided the outer pressure exceeds that within the cell. But if the cells are already full of air no amount of pressure can fill them with liquid, since the confined air cannot pass out through the cell walls. No more can a vacuum extract the air from the cells.*

Green wood and sapwood contain much less air in the lumena than heartwood and seasoned wood.

But time will not permit further discussion. Between the cells of

*Mr. Tiemann writes: "I would like to mention here another hypothesis in regard to the penetration of the conifers with creosote. The resin ducts and medullary rays contain semi-fluid resin, and all the tissues appear to be permeated with it. Resin has an affinity for creosote as sugar has for water. Is it not likely that the resin permeating the cells draws in the creosote, and unites with it in solution, the same as sugar will with water? This would account for the readiness with which the creosote enters the tracheids of a wood like loblolly pine, even though air be present in the lumena of the cells."

all woods are minute interstices or air spaces which communicate with the outer air through the medullary rays and the lenticels of the bark. What influence these minute passages might have upon the penetration of liquids is entirely an unknown quantity. Enough has been said to show the importance of a more complete and exhaustive study of the subject of penetrability from the anatomical, physiological and physical standpoint.

Note regarding illustrations: The photo micrographs, Figs. 1 to 2, 4 to 6 and 10 to 15, were made by the author expressly for this paper and have all been enlarged to exactly the same scale, so that they are directly comparable. That is to say, Figs. 2 and 5, which are highly magnified, are comparable, and all of the other figures, which are magnified to a lower power.—H. D. T.

Appendix D.

PRACTICE IN GROUPING OF SPECIES.

The Committee sent out a circular letter as follows:

(*Circular No.* 112.)

The Committee on Wood Preservation has appointed a Sub-Committee on the Adaptability of Woods. This Sub-Committee desires to gather information concerning the classification of species that take treatment together, and to record experiences, if any, with the strength of treated timber.

Will you be good enough to fill out the following blank, in so far as you can consistently do so, and assist the Committee in its work?

(1) *Species of timber accepted for treatment.*

(2) *Grouping of species, etc.*

Class of timber (ties, etc.).

Retort:

Steam (pressure; time).

Air (pressure; time).

Fluid (pressure; temperature).

Vacuum (inches; time).

Notes.—Penetration; sap; heart; quantity injected per cubic foot, etc.

(3) Please supply copies of specifications under which work is performed.

(4) Please record in detail any experiences relative to deficiency of strength of treated timber, stating species and process, retort conditions, and condition of timber before treatment.

Certain individuals were further addressed to obtain opinions based upon experience. The summary of the replies is given in Table I, and abstracts of the replies are given below.

ABSTRACTS OF REPLIES TO CIRCULAR NO. 112.

The International Creosoting & Construction Company.

We endeavor to separate the different grades of pine as much as it is possible to do in practice. In the handling of a large volume of business, however, it is not always possible to rigidly enforce these instructions. This applies to the different species of pine. We do not separate according to sapwood unless, of course, we have an order calling for strictly heart, which is very seldom, and in this event it is necessary to treat it to itself.

Atlantic Creosoting & Wood Preserving Works, Norfolk, Va.

We treat almost exclusively pine with occasional gum. We have

treated some little oak, and our practice is always to separate the species of wood in each cylinder, loading separately longleaf and shortleaf pine. If the quantity to be treated is sufficiently large, we endeavor to separate the heartwood from the sap, but we do not advocate creosoting heart pine and believe it more difficult to satisfactorily penetrate than oak, gum and other so-called hardwood. Our experience with gum and red oak is that it can be satisfactorily treated.

W. F. Sherfesee, Chief of Office of Wood Preservation, Forest Service.

As the sapwood of all species can be impregnated without difficulty when reasonably air-dry, the writer presumes that it is only with the relative ease of impregnation of heartwood that you are interested. Moreover, it is probably taken for granted that green wood and dry, large dimension stuff and small timbers, are not to be grouped together, but that the moisture content and size of the timber are to be considered as fairly uniform. It would, of course, be easy enough to discuss the probable behavior of certain species from a purely theoretical point of view, taking into consideration the physiological structure of the different timbers, their organic cell contents, etc.; but experience has shown very emphatically that the controlling factors which influence the absorption of different preservatives by different processes are so complex that theoretical deductions are erroneous more often than correct. It is oftener necessary to find an explanation for known results than it is possible to predict such results with accuracy.

Octave Chanute. (See Table No. I.)

The writer believes that this grouping is chiefly controlled by the specific gravity of the wood when perfectly dry, although it is seldom indeed that it is in that condition when treated. If you will insert the dry weight per cubic foot in the margin of our grouping, the above fact will appear. Something, however, is due to texture. Thus, hemlock, which weighs 26 lbs. per cubic foot perfectly dry, is as hard to inject as red oak, which weighs 43 lbs. per cu. ft.

Something is also due to locality of growth. Upland red oak is more refractory than lowland red oak, and we allow for this in the length of treatment. Ties seasoned in close piles require more time than when stacked in open piles, and when we are in doubt we select a few ties from the pile and ascertain their weight per cubic foot, having a trough expressly made to measure the water displacement.

Samuel M. Rowe.

The writer herewith submits a statement with relation to proper classification of our American woods with reference to treating.

The writer has relied upon a long series of tests as to the natural absorptive powers of each kind to take up water when immersed in a normal degree of dryness, believing it would aid in judging of the nature of the timber in practical treating.

In practice it is found that woods will absorb in the course of the ordinary methods of impregnation under pressure of 100 lbs., while

in the solution about as much as is taken up by immersion in 28 to 30 days, and on this basis the following table is constructed.

Class A, those that absorb less than 20 per cent. in volume,

Class B, those absorbing from 20 to 40 per cent., and Class C, those absorbing over 40 per cent.

This gives more than 75 per cent. in the one class (B), making the exceptions hardly worth considering, and it hardly seems worth while to attempt a classification.

TABLE II.

S. M. Rowe's Classification of Timbers for Treating.

NAME	Loc.	Wt. Cu. Ft.	Abs. Wt. Per cent.	A	B	C
Ash (White)	Mich.	37.8	.265	—	x	—
Beech	Ind.	38.7	.214	—	x	—
Cedar (White)	Mont.	20.8	.265	—	x	—
Cherry (Wild)	Ill.	45.4	.170	x	—	—
Cottonwood	Mont.	24.6	.383	—	x	—
Cypress	Texas.	37.2	.246	—	x	—
Elm (Red)	Ill.	33.1	.215	—	x	—
Elm (Rock)	Mich.	46.9	.216	—	—	—
Fir (Douglas)	Mont.	31.7	.212	—	x	—
Fir (Balsam)	New Mex.	25.4	.227	—	x	—
Gum	Texas.	32.8	.254	—	x	—
Hackberry	Ill.	40.8	.290	—	x	—
Hemlock	Mich.	25.6	.323	—	x	—
Hickory (s. b.)	Mich.	46.8	.200	x	or x	—
Linden	Ill.	27.3	.526	—		x
Maple (Sugar)	Mich.	46.4	.266	—	x	—
Oak (White)	Mo.	46.0	.249	—	x	—
Oak (Black)	Ind.	41.4	.157	x	—	—
Oak (Red)	Ind.	43.5	.169	x	—	—
Oak (Water)	Ind.	46.9	.132	x	—	—
Pine (long leaf.)	Texas	34.7	.241	—	x	—
Pine (sht. leaf.)	Texas	35.2	.249	—	x	—
Pine (So. Yellow)	Texas	38.2	.231	—	x	—
Pine (Mtn.)	New Mex.	28.8	.225	—	x	—
Pine (Mtn.)	Colo.	21.2	.299	—	x	—
Pine (Black Hills)	S. D.	29.3	.216	—	x	—
Pine (Mich. wh.)	Mich.	28.2	.494	—	—	x
Pine (Pinion)	Colo.	24.8	.324	—	x	—
Pine (Bull)	Mont.	26.5	.220	—	x	—
Pine (Norway)	Mich.	25.6	.238	—	x	—
Pine (Northern wh.)	....	24.3	.278	—	x	—
Pine (White)	New Mex.	25.3	.225	—	x	—
Pine (White)	Colo.	23.4	.281	—	x	—
Pine (diseased)	Wyo.	27.8	.402	—	x	—
Pine (Mexican, 8 var.)	....	32.1	.318	—	x	—
Spruce	New Mex.	31.3	.274	—	x	—
Spruce (White)	Colo.	24.9	.268	—	x	—
Spruce (White)	Mont.	20.8	.250	—	x	—
Spruce (Red)	Colo.	28.7	.261	—	x	—
Spruce (Red)	New Mex.	33.2	.164	x	—	—
Sycamore	Ill.	41.0	.366	—	x	—
Tamarack	Mont.	32.9	.228	—	x	—

Class A 20 per cent or less.
Class B 20 per cent. to 40 per cent.
Class C over 40 per cent.

The conditions of climate and other causes and conditions may vary as well as differences in the same woods in different locations, so that it will be difficult to cover all cases. I have never believed in guessing or jumping to conclusions when it is possible to get some-

thing that will aid to guide, and I am sure that this method, no matter how many classes are desired, will be an aid.

F. J. Lass, Mechanical Engineer of the Mexican Central Railroad Company, at Aguascalientes, Mexico, supplies the details of treatment of Mexican pine and Texas pine by the Wellhouse process. The treatment aims at an absorption of one-third of a pound of zinc chloride to the cubic foot. On account of the very dry porous condition of the Mexican pine a weak solution of 1.25 per cent. is used, and this is raised to 2 per cent. for green timber or the more dense Texas pine.

The cases cited are:

Steaming, 20 lbs. for 3 to 7 hours; *vacuum,* 21 in., 1 to 2 hours; *solution,* 100 lbs. for ¾ to 6½ hours; *glue,* 100 lbs. ¾ to 1½ hours; *tannin,* 100 lbs., ¾ to 1¾ hours.

This plant is now being converted into one for treating ties with crude oil that has a heavy asphaltic base. The treatment varies with the class of timber and its condition of seasoning.

A letter from Lincoln Bush, Chief Engineer of the D., L. & W. R. R., supplies details of treatment by creosote of prime yellow long-leaf material for bridge ties. Average material received 12.42 lbs. of creosote per cu. ft. with following treatment: Steam 25 lbs. for 8¼ hours; vacuum, 26.75 in. for 3.92 hours; oil at 157½ lbs. pressure for 3 hours. Dense and green material required 25 lbs. of steam for 11 hours, and 28 in. of vacuum for 4½ hours; oil at 170 lbs. for 3 hours; receiving 17.32 lbs. per cu. ft.

In the treating with creosote of wedges and guard rails for the Bergen Tunnel, the following results are quoted:

Material.	Steam.		Vacuum.		Oil.		Absorp.
Longleaf Pine.	Pres. Lbs.	Time. Hrs.	Inches.	Time.	Pressure	Time.	
Guard Rails.....	25	6.0	26	4.12	165	3.12	12.28
Ties...........	23	3.4	27	3.09	156	2.7	12.76
Wedges........	25	3.3	27	2.8	132	2.56	12.67

The steaming and vacuum were not necessary in the case of thoroughly seasoned timber.

T. E. Calvert, Chief Engineer of the Chicago, Burlington & Quincy Railway, has communicated to the Committee the preliminary results of experiments at Galesburg, Ill., by F. J. Angier to determine the absorption of various species of woods treated together under like conditions, using the Card process and an experimental retort. Three or four ties of each kind were treated. All the ties used in this treatment were seasoned at least eight months and are carefully selected, so as to be as free as possible from knots and other defects. No steaming is allowed and no initial vacuum. In each case the solution,

consisting of 23 per cent. creosote by volume, and water, containing 5 per cent. of zinc chloride, is introduced at a temperature of 180° F., and a pressure of 150 lbs. maintained for 3 hours. This is followed by a 1-hour vacuum.

Species.	No. Ties Treated.	Wt. per cu. ft. before Treatment.	Gain in wt. per cent.	Absorption, per tie.		Net Gain after vacuum per cent.
				lbs. Zn. Cl.	lbs. creosote.	
Cypress	4	27.3	98.01	4.09	16.96	80.0
Cottonwood	4	23.2	88.31	2.11	12.59	49.4
Willow	4	28.6	82.03	2.42	14.43	58.0
Birch	4	38.2	67.93	2.75	16.45	53.0
White Elm	4	34.4	60.50	2.11	12.59	48.5
Poplar	4	27.0	58.74	1.71	10.24	45.2
Soft Maple	4	32.5	50.58	1.69	10.12	44.0
Hemlock	4	31.6	49.46	1.78	10.64	37.6
Loblolly	4	32.3	44.22	1.47	8.80	27.3
Hard Maple	4	42.0	40.72	1.75	10.46	33.5
Red Gum	3	33.0	36.99	1.45	8.67	29.0
Beech	4	46.0	36.57	1.70	10.18	27.5
Red Oak	3	44.0	35.87	2.12	12.65	32.0
Ash	3	42.3	34.47	1.69	10.12	30.3
Hickory	4	48.4	23.85	1.09	6.55	20.6
Tamarack	4	40.8	20.29	.81	4.83	20.3
White Oak	4	47.0	7.97	.39	2.30	5.98

Eppinger and Russell Co., Long Island City, N. Y.

It is our custom here to confine ourselves to the creosoting of yellow pine, both long and shortleaf, in which we inject from ten to 24 lbs. of oil per cu. ft. We separate as much as possible the longleaf from the shortleaf, also the sapwood from the heartwood. The seasoned lumber is also treated separately from the green lumber.

When the lumber is perfectly seasoned, we omit the steam and vacuum process, but when not seasoned we steam from three to twenty hours, and a vacuum from two to eight, depending on the condition of the lumber being treated.

Circular 146, Forest Service, "Experiments with Railway Cross-Ties," by H. B. Eastman. Douglas fir and tamarack seasoned ties were treated with a 6 per cent. solution of zinc chloride with an injection of 0.786 lb. of pure chloride per cu. ft. of timber. The increase in weight per tie was nearly 51 lbs. in the case of tamarack, and 36 lbs. for Douglas fir peeled when cut, and 40 lbs. for Douglas fir peeled directly before treatment.

Circular 132, Forest Service, "The Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-Ties," by W. H. Sherfesee, gives the following table of absorption in relation to weight of wood, and shows also that there is very little difference in the absorption of hemlock and tamarack.

Weight per Cubic Foot Before Treatment.	Percentage of Ties Absorbing Over 10 Pounds per Cubic Foot.	
Pounds.	Hemlock.	Tamarack.
57	0	0
56	5	0
55	9	7
54	13	12
53	16	17
52	19	21
51	21	26
50	24	31
49	27	36
48	30	40
47	33	44
46	36	48
45	39	52
44	42	56
43	46	60
42	49	64
41	53	68
40	56	72
39	60	76
38	64	..
37	68	..
36	72	..
35	76	..
34	80	..
33	85	..
32	90	..
31	94	..
30	99	..
29	100	..
28	100	..
27	100	..

Circular 136, Forest Service, "The Seasoning and Preservative Treatment of Arborvitae Poles," by C. Stowell Smith, gives the effect of rate of growth upon penetration and absorption of arborvitae poles when treated by the open tank method.

Number of rings to last inch.	Average absorption, lbs.	Average penetration in.
10-20	46	0.58
21-30	44	0.49
31-40	39	0.40
41-60	37	0.39

Circular 147, Forest Service, "Progress in Chestnut Pole Preservation," by Howard F. Weiss, shows the relation between rate of growth upon penetration and absorption of creosote in chestnut poles treated by the open tank method. This is shown by the diagram.

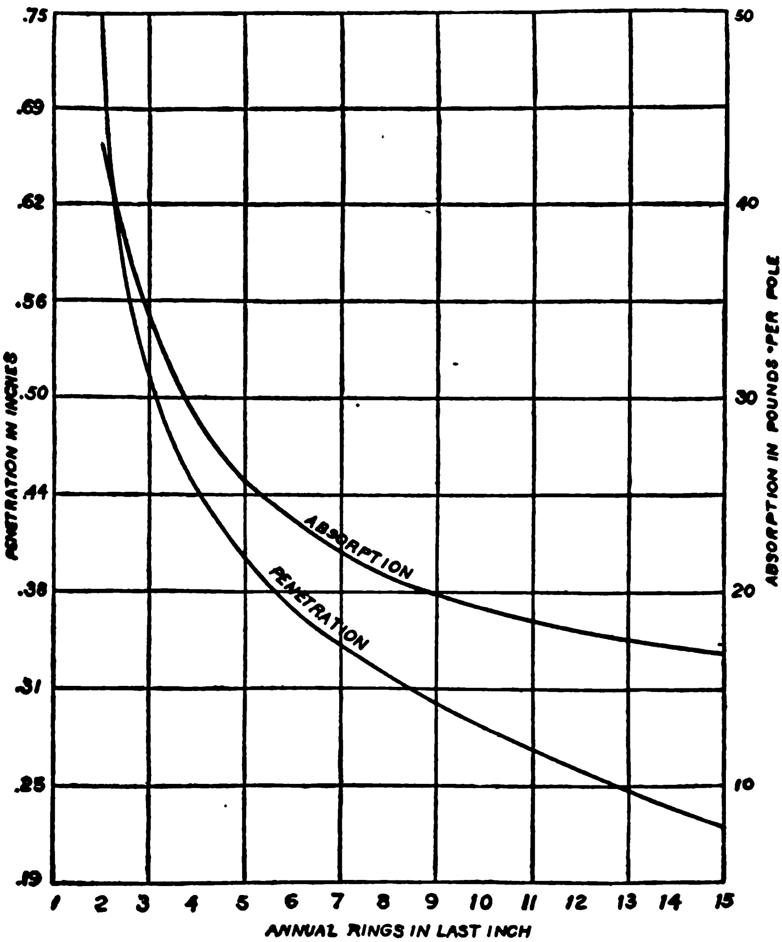
Circular 151, Forest Service, "The Preservative Treatment of Loblolly Pine Cross-Arms," by W. F. Sherfesee, describes experiments to determine, among other things, the relative absorption of sapwood and heartwood, and the conclusion is as follows:

"During the process of manufacturing the arms they should be graded into three classes: Arms that contain at least 75 per cent. of heartwood; arms that contain at least 75 per cent. of sapwood, and arms that occupy an intermediate position."

The above circulars of the Forest Service contain valuable descriptions of the seasoning of timber and of the effect of various elements

upon the treating process. These matters are to be taken up in further reports of the Committee.

E. O. Faulkner, Atchison, Topeka & Santa Fe.—The writer begs to say that at our Somerville (Texas) Plant we group only the pines—longleaf, shortleaf and loblolly—treating our ties by the Rueping process,



RELATION OF RATE OF GROWTH WITH PENETRATION AND ABSORPTION OF CREOSOTE IN CHESTNUT POLES.

using 75 lbs. initial air pressure, taking about 30 minutes, followed by creosote pressure, 175 lbs., for 1 hr. 30 m., then after the oil has dropped out of the impregnating retort, a vacuum for 1 h. 45 m., taking in all about 4 h. 25 m. for each run.

While we have had a few other hardwoods for test purposes, they are not sufficiently numerous to tabulate, consequently the only

other woods are the gums and red oak; we get enough of each kind so that we have not had to treat them mixed. We use the same method of treatment, excepting that we put in 85 lbs. of air followed by 200 lbs. of creosote pressure, and a vacuum as before.

With the pines we get complete penetration of the sapwood and a little way into the heart, but not much; the oil used varying from 4¼ to 4¾ lbs. to the cu. ft. of timber.

With the gum and red oak we get very little into the heart, although the sap is well treated and the quantity used varies from 4 to 4½ lbs. per cu. ft.

We treat nothing but seasoned timber.

At the Albuquerque Plant, we treat the red spruce with creosote by the Rueping process, using 80 lbs. of air, 200 lbs. creosote pressure followed by the usual vacuum; and the other Rocky Mountain pines we treat with California crude oil, heated to 200 degrees F., using 200 lbs. oil pressure, followed by a drip vacuum to clean the surface of the wood, which otherwise would be hard to handle.

Grouping Reported by Ayer & Lord Tie Co.

(1) The red oaks—ties.
(2) Pine, except longleaf—ties, lumber and piling.
(3) Ash, elm, gum, beech, maple, sycamore—ties.
(4) Longleaf—paving blocks.

Various processes are used, including Rueping, Burnettizing and Straight Creosoting. Steaming is used up to 20 lbs. and 4 hours when necessary.

Grouping Reported by New York Central Lines.

GROUP NO. 1.

15. Red Oak.
16. Pin Oak or Swamp Spanish Oak.
17. Black Oak or Yellow Oak.
18. Spanish Oak.
19. Water Oak or Jack Oak.
20. Scarlet Oak.
21. Shingle Oak or Laurel Oak.
22. Willow Oak.
23. Honey Locust or Honey Shucks.

GROUP NO. 2.

24. Beech.
25. Sweet Birch or Black Birch.

GROUP NO. 3.

26. Sugar Maple or Rock Maple.
27. White Ash.
28. Bitternut or Swamp Hickory.
29. Shellbark Hickory.
30. Mockernut Hickory.
31. Pignut Hickory.
32. Hackberry, Sugarberry or Nettle Tree.

GROUP NO. 4.

33. Silver Maple, Soft Maple or White Maple.
34. Red Maple, Swamp Maple or Soft Maple.
35. Sycamore.
36. Red Birch or River Birch.
37. White Elm, American Elm or Water Elm.
38. Cork Elm, Rock Elm or Hickory Elm.
39. Tupelo, Pepperidge, Sour Gum or Black Gum.

GROUP NO. 5.

40. Red Gum, Sweet Gum or Liquidambar.

GROUP NO. 6.

41. Cypress.

The Barber Asphalt Paving Co., Maurer, N. J.

So far, we have treated shortleaf pine, longleaf pine, spruce and hemlock. We were somewhat surprised at the good results obtained on the spruce, as we injected an ordinary twelve-pound treatment in one-inch stuff without difficulty, although we had always believed that spruce was hard to treat. The spruce was 'house-dry' and made up into parts of lead cable reels before being treated.

We have never grouped the few species of wood which we have treated, treating each species by itself.

Regarding the class of timbers, we treat ties, piles, cross-arms, dock and bridge timbers and wood paving blocks.

Shreveport Creosoting Co., Ltd., Shreveport, La. Following are specifications under which the treating of the species was performed:

"Vacuum of 20 in. was applied as soon as cylinder was closed, holding this vacuum from forty-five minutes to one hour. The creosote was then introduced, at a temperature not to exceed 190 or 200 degrees, under the vacuum, allowing the vacuum to die as the cylinder filled. The cottonwood and red elm absorbing a small percentage, while the cylinder filled, the oak absorbing practically none. The pump pressure is immediately applied, and the required amount of creosote can be impregnated within three hours under pressure not to exceed 150 pounds."

THE CREOSOTING OF TIMBER GROWN IN ENGLAND.

By W. B. Havelock, Brocklesby, Lincolnshire, Eng. (Transactions of Royal Arboricultural Society, Vol. 20, 12.)

"The following (see table) are the results of tests made in order to ascertain how much creosote oil would be absorbed by various kinds of timber under high pressure. Fifty-six kinds of timber were experimented with, all of which were grown on the estate of the Earl of Yarborough, Brocklesby Park, Lincolnshire. The timber was sawn to the sizes stated below, and naturally seasoned in the open air, the creosote being injected under a pressure of 80 to 85 lbs. per sq. in. (approximately 6 atmospheres) for 3 hours. The creosote (sp. gr. 1,040, costing 2¾d. to 3d. a gallon delivered to the purchaser's yard) was warmed by steam during use, and a vacuum of 9 lbs. was obtained in the cylinder before it was injected. The last column of figures shows the amount of creosote absorbed per cubic foot of the wood submitted to the process."

EXPERIMENTS TO DETERMINE ABSORPTION OF CREOSOTE. W. B. HAVELOCK.

Reference No.	SPECIES OF TIMBER	No. of Pieces.	Size of Pieces.	Weight before Creosoting.	Weight after Creosoting.	Total Increase in Weight.	Contents of each Piece	Weight of Creosote Oil absorbed by each Piece.	Weight of Creosote Oil absorbed per Cubic Foot.
			Ft. Ins.	Lbs.	Lbs.	Lbs.	Cu. Ft.	Lbs.	Lbs.
33	Scots Pine (Pinus sylvestris)	2	6x3½x3½	33[illegible]	63[illegible]	30[illegible]	.51	15.25	29.90
14	Menzies Spruce (Picea sitchensis)	2	6x3½x3	26[illegible]	48[illegible]	22[illegible]	.43	11.06	25.72
10	Heavy-wooded Pine (Pinus ponderosa)	2	6x3½x3½	30	52[illegible]	22[illegible]	.51	11.31	22.17
22	Beech (Fagus sylvatica)	4	6x3½x3½	106	150[illegible]	44[illegible]	.51	11.21	21.98
60	Hornbeam (Carpinus Betulus)	2	6x3½x3½	54[illegible]	76[illegible]	21[illegible]	.51	10.93	21.43
34	Sycamore (Acer Pseudoplatanus)	2	6x3½x3½	40[illegible]	62[illegible]	21[illegible]	.51	10.87	21.31
37	Horse Chestnut (Aesculus Hippocastanum)	2	6x3½x3½	45[illegible]	66[illegible]	21[illegible]	.51	10.68	20.94
31	Norway Spruce (Picea excelsa)	2	6x3½x3½	33[illegible]	53	19[illegible]	.51	9.62	18.86
70	Ash (Fraxinus excelsior)	6	6x3½x3½	142	194	52	.51	8.66	16.98
41	Wellingtonia (Sequoia gigantea)	2	6x3½x3½	27[illegible]	44[illegible]	16[illegible]	.51	8.43	16.53
158	Trembling Poplar (Aspen) (Populus tremula)	5	6x3½x3½	104	143[illegible]	39[illegible]	.51	7.85	15.39
40	Silver Fir (Abies pectinata)	3	6x3½x3½	46[illegible]	69[illegible]	22[illegible]	.51	7.54	14.78
21	Birch (Betula alba)	1	6x3½x3½	22[illegible]	30[illegible]	7[illegible]	.51	7.12	13.96
38	Red Elm (Ulmus campestris)	4	6x3½x3½	99[illegible]	126[illegible]	26[illegible]	.51	6.71	13.15
58	Apple (Pyrus Malus)	2	4x3½x3½	36	44[illegible]	8[illegible]	.34	4.31	12.67
61	Weymouth Pine (Pinus Strobus)	2	6x3½x3½	28[illegible]	41[illegible]	12[illegible]	.51	6.37	12.49
25	Black American Spruce (Picea nigra)	2	6x3½x3½	32[illegible]	44[illegible]	12	.51	6.00	11.76
[illegible]	Douglas Fir (Pseudotsuga Douglasii)	5	6x3½x3½	84[illegible]	110[illegible]	26[illegible]	.51	5.22	10.23
71	Black Poplar (Populus nigra)	2	6x3½x3½	34	43[illegible]	9[illegible]	.51	4.56	8.94
63	Red Oak (Quercus rubra)	4	6x3½x3½	120[illegible]	135	14[illegible]	.51	3.59	7.03
73	Huntingdon Willow (Salix alba)	4	6x3½x3½	59[illegible]	72[illegible]	13[illegible]	.51	3.37	6.60
16	Lobb's Arbor-Vitae (Thuya gigantea)	3	6x3½x3½	57[illegible]	64[illegible]	6[illegible]	.51	2.25	4.41
32	Larch (Larix europea)	2	6x3½x3½	43[illegible]	46[illegible]	3[illegible]	.51	1.56	3.06
4	Acacia (Robinia Pseudacacia)	6	6x3½x3½	162[illegible]	166[illegible]	3[illegible]	.51	0.64	1.25

TABLE I—SUMMARY OF REPLIES TO CIRCULAR.

	1. O. Chanute.			2. Albuquerque Plant. A. T. & S. Fe.		3. L. & N. R. R.		4. Wyckoff P. & C. Co.	5. C. & P. Ry.
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 1	Group 2	Group 1	Group 1
Species.	Red Oak. Black Oak. Water Oak. Beech. Hickory. Sassafras. Hard Maple. Hemlock. Tamarack. Douglas Fir. Longleaf Pine.	Ash. Hackberry. Short Leaf Pine. Sycamore. Birch.	Red Gum. Black Gum. Spruce. Cypress. Loblolly Pine. Poplar. Red Elm.	Western Pine.	Douglas Fir.	Long Leaf. Short Leaf. Loblolly Pine.	Long Leaf. Short Leaf. Loblolly Pine.	Yellow Pine.	Mountain Pine.
Class of Timber, Ties, etc.	Ties.	Ties.	Ties.	Ties. (Seasoned).	Ties. (Seasoned).	Bridge and Culvert. (Mainly Green).	Piles. (Mainly Gr'n)	Ties, Piles, Paving Blocks, Bridge Timbers.	Ties.
Steam Pressure	20 lbs.	20 lbs.	20 lbs.	....	....	15 lbs.	20 to 30 lbs.	30 to 40 lbs.	20 lbs.
Time	1 hour.	1 hour.	1 hour.	....	....	10 to 12 hours.	12 to 15 hours	3 to 6 hours.	2 hours or more
Air Pressure	....	....	....	....	85 lbs.	....	....	....	....
Time	....	....	....	....	½ hour.	....	....	....	....
Fluid or Process	Zinc Chl.	Zinc Chl.	Zinc Chl.	Crude Oil.	Rueping (Creosote)	Creosote.	Creosote.	Creosote	
Pressure	100 lbs.	100 lbs.	100 lbs.	200 lbs.	250 lbs.	125 lbs.	125 lbs.	....	100 lbs.
Time	3 to 5 hours.	¾ to 1 hour.	¼ to ½ hour.	....	....	....	....	....	....
Temperature	150° F.	150° F.	150° F.	200° F.	....	164° F.	164° F.	At least 175° F.	192°F.
Vacuum	22 to 26″	22 to 26″	22 to 26″	26″	26″	22 to 26″	22 to 26″	24″ or more	20″
Time	1 hour.	1 hour.	1 hour.	1 hour.	1 hour.	5 hours.	5 to 7 hours	Until no Moisture comes from Retort.	1 hour.
Penetration	Thru. Ends.	Thru. Ends.	Thru. Ends.	....	....	....	....	....	....
Sap	Entire.	Entire.	Entire.	Entire.	Entire.	Entire.	Entire.	Entire.	....
Heart	Variable.	Variable.	Variable.	....	....	Variable.	Variable.	In Ends.	....
Quantity injected, per cubic foot, etc.	½ lb. Dry Zchl.	½ lb. Dry Zchl.	½ lb. Dry Zchl.	15 lbs.	4.61 lbs.	12 lbs.	20 to 22 lbs.	12 lbs. or more.	4.48 gal. per tie.

Note—The various steps of retort process are not necessarily in sequence. Where space is left blank information is not available.

TABLE I—CONTINUED.

	6. C. & N. W. Ry., Escanaba, Mich.					7. G. N. Ry.	8. N. P. Ry., Brainerd, Minn.		
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 1	Group 1	Group 2	Group 3
Species.	Hemlock. Tamarack. White Pine.	Hemlock. Tamarack. White Pine.	Beech. Hard Maple.	Yellow and White Birch	Ash.	Red Spruce. Douglas Fir.	Jack Pine (Seasoned).	Red Oak.	Birch. Ash. Elm.
Class of Timber, Ties, etc.	Dry Ties.	Green Ties.	Green and Dry Ties	Green and Dry Ties.	Ties.	Ties. (Sawed).	Ties. (Seasoned.)	Ties. (Seasoned).	Ties. (Seasoned).
Retort:									
Steam Pressure	20 lbs.	20 lbs.	20 lbs.	20 lbs.	20 lbs.	20 lbs.			
Time	2 hours.	2½ hours.	3 hours.	3 hours.	3 hours.	4 to 6 hours.			
Air Pressure									
Time									
Fluid or Process	Wellhouse.	Card.	Card.	Card.	Card.	Zinc Chl.	Lowry. (Creosote.)	Lowry. (Creosote.)	Lowry. (Creosote.)
Pressure	120 lbs.	120 lbs.	120 lbs.	120 lbs.	120 lbs.	100 lbs.	45 lbs.	155 lbs.	65 lbs.
Time							½ hour.	1 hour.	½ hour.
Temperature	150° F.	200° F.	200° F.	200° F.	200° F.	110 to 140° F.			
Vacuum	26″	26″	26″	26″	26″	23½ to 25″	25″	25″	25″
Time	1 hour.	1 hour.	1 hour.	1 hour.	1 hour.	1 to 2 hours.	½ hour.	½ hour.	2 hours
Penetration						0.1975% of Vol.			
Sap							Entire	Entire.	Entire.
Heart							Slight.	Entire.	Entire.
Quantity injected, per cubic foot, etc.	0.450 lb. Zinc.	0.400 lb. Zinc. 1.48 lbs. Creosote.	0.400 lb. Zinc. 1.48 lbs. Creosote.	0.450 lb. Zinc 2.25 lbs. Creosote.	0.60 lb. Zinc. 3.00 lbs. Creosote.	0.315 lb.	6½ lbs.	6½ lbs.	6½ lbs.

TABLE I—CONTINUED.

	9. Sou. Creo. Co. Slidell, La.				10. Am. Creo. Co.				
	Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4	Group 5
Species.	Pine. (Freshly Cut.)	Pine. (½ Green.)	Pine. (Dry.)	Pine. (Very Dry.)	Pines: Loblolly, Short Leaf.	Soft Maple. Rock Elm. Sycamore.	White Elm.	Oaks: Red, Black, Pin, Willow.	Beech. Birch.
Class of Timber, Ties, etc.	Piles and Ties.	Piles and Ties.	Piles and Ties.	Piles and Ties.	Ties (Seasoned.)	Ties (Seasoned.)	Ties (Seasoned.)	Ties (Seasoned.)	Ties (Seasoned.)
Retort:									
Steam Pressure	50 to 60 lbs.	45 lbs.	....	....	....	....	....	....	....
Time	6 to 24 hours.	6 to 24 hours.	....	....	....	....	....	....	....
Air Pressure	....	....	....	....	....	....	....	....	....
Time	....	....	....	....	....	....	....	....	....
Fluid or Process	Creosote.	Creosote.	Creosote.	Creosote.	Lowry.	Lowry.	Lowry.	Lowry.	Lowry.
Pressure	125 lbs.	125 lbs.	125 lbs.	125 lbs.	50 lbs.	60 lbs.	80 lbs.	175 lbs.	175 lbs.
Time	....	....	....	....	....	....	....	....	....
Temperature	160° F.	160° F.	160° F.	160° F.	180° F.	180° F.	180° F.	180° F.	180° F.
Vacuum	22"	22"	22"	22"	25"	25"	25"	25"	25"
Time	....	....	....	....	¾ hour.	¾ to 1 hour.	¾ hour.	¾ to 1 hour.	1 hour.
Penetration	Varies according to the per cent of sap.				....	....	....	....	....
Sap	....	....	....	....	Entire.	Entire.	Entire.	Entire.	Entire.
Heart	....	....	....	....	Slight.	Entire.	Entire.	Entire.	Entire.
Quantity injected, per cubic foot, etc.	10 to 24 lbs.	10 to 24 lbs.	10 to 24 lbs.	10 to 24 lbs.	Timber absorbs all it will, and then surplus oil is removed, leaving 2½ gallons per tie				

TABLE I—CONTINUED.

	10. Am.Creo.Co.		11 S. P. Co. W. Oakland, Cal.	12, Atl. Creo. & W. Pres Co., Norfolk, Va.						
	Group 6	Group 7	Group 1	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Species.	Red or Sweet Gum.	Ash. Hickory. Pecan. Hard Maple. Black Walnut (Except all heart.) White Walnut.	Oregon Pine. Shasta Pine.	Bull Pine. Slash Pine.	Black Gum. Black Cypress.	Short Leaf Pine. Birch.	Long Leaf Pine.	Red Oak. Black Oak.	White Oak. Post Oak.	Sweet Gum.
Class of Timber, Ties, etc.	Ties (Seasoned.)	Ties (Seasoned.)	Sawn Ties (Green.)		All timber of the same comparative cross-section.					
Retort:										
Steam Pressure	......	......	......	40 lbs.	30 lbs.	35 lbs.	40 lbs.	25 lbs.	25 lbs.	25 lbs.
Time	......	......	......	5 hours.	3 hours.	5 hours.	6 hours.	3 hours.	3 hours.	3 hours.
Air Pressure	......	......	......	......	......	......	......	......	......	......
Time	......	......	......	......	......	......	......	......	......	......
Fluid or Process	Lowry.	Lowry.	Creosote. Boiling	Creosote.	Creosote.	Creosote.	Creosote.	Creosote.	Creosote.	Creosote.
Pressure	175 lbs.	175 lbs.	Not over 140 lbs.	50 lbs.	50 lbs.	60 lbs.	100 lbs.	50 lbs.	75 lbs.	75 lbs.
Time	......	......	......	......	......	......	......	......	......	......
Temperature	180° F.	180° F.	216° F.	125° F.	125° F.	125° F.	125° F.	125° F.	125° F.	125° F.
Vacuum	25″	25″	......	21″	21″	21″	21″	21″	21″	21″
Time	¾ to 1 hour.	¾ to 1 hour	......	6 hours.	4 hours.	4 hours.	6 hours.	4 hours.	4 hours.	4 hours.
Penetration	......	......	¾″ Black Oil.	1½″	1½″	1½″	1½″	1½″	1½″	1½″
Sap	Entire.	Entire.	......	......	......	......	......	......	......	......
Heart	Slight.	(Except Blk. Walnut)								
Quantity injected, per cubic foot, etc.			10 lbs.	12 lbs.	12 lbs.	12 lbs.	12 lbs.	12 lbs.	12 lbs.	12 lbs.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 1	Group 3	Group 5
Species	Short Leaf Pine.	Long Leaf Pine.	Long Leaf Pine.	Long Leaf Pine.	Short Leaf Pine.	Yellow Pine.	Spruce.	Red Oak. Cottonwood.	Red Oak. Red Elm.	Red Oak. Red Elm. Cottonwood.
Class of Timber, Ties, etc.	Ties.	Piling.	Paving Blocks.	Paving Blocks.	Paving Blocks.	Piling.	Cable Reels and Lagging	Ties.	Ties.	Ties.
Retort:										
Steam Pressure	Air	30 lbs.	10 lbs.	10 lbs.	10 lbs.	20 lbs.	4 lbs.	40 lbs.	40 lbs.	40 lbs.
Time	Dried	7 hrs.	3 hrs.	3 hrs.	3 hrs.	5 hrs.	4 hrs.	1 hr.	1 hr.	1 hr.
Air Pressure	50 lbs.									
Time	½ hr.									
Fluid or Process										
Pressure	100 lbs.	65 lbs.	160 lbs.	130 lbs.	130 lbs.	95 lbs.		135 lbs.	125 lbs.	125 lbs.
Temperature	140° F.	140° F.	160° F.	160° F.	150° F.	140° F.	140° F.	190° F.	190° F.	190° F.
Vacuum	23"	25"	24"	24"	25"	26"	25"	20"	20"	20"
Time	1 hr.	6 hrs.	4 hrs.	4 hrs.	4 hrs.	5 hrs.	4 hrs.	45 m.	45 m.	45 m.
Penetration	*	†	Compl'te	Not Observ'd	Not Observ'd	Not Observ'd	Not Observ'd	Entire.	Entire.	Entire. (Except Oak)
Sap								8 lbs. Oak.	8 lbs. Oak. 36 lbs. Elm.	8 lbs. Red Oak
Heart										6 lbs. Oak. 36 lbs. Elm.
Quantity injected per cubic foot, etc.	5 lbs.	12 lbs.	20 lbs.	18 lbs.	16 lbs.	20 lbs.	12 lbs.	44 lbs. Cottonw'd		44 lbs. Cottonwood

*All the sap, ¼" to ¾" on heart faces.
†2" to 3" on sap at butt; complete penetration on tops.

DISCUSSION.

The President:—We will now consider the report of the Committee on Wood Preservation. Mr. A. L. Kuehn is chairman, and will make a preliminary statement.

Mr. A. L. Kuehn (American Creosoting Company):—This is the first report of the Committee on Wood Preservation. The subject in America is almost brand-new, with one or two exceptions, so in a sense the Committee is in a new field. The report, therefore, is not detailed and specific; it is more or less general. It is intended to be an introduction of the subject, rather than a thorough and exhaustive report or investigation. The peculiarity of wood preservation is that it takes a long time before it is known whether the wood has actually been preserved to the extent to which it is supposed to be preserved, so that investigation will necessarily extend over a long period of years. A full, conclusive statement of results obtained on a large scale in America will require a number of years. Necessarily the work of this Committee, to be successful, will have to be the work of several years, more so, perhaps, than the reports of other committees.

The report has been divided into four parts. The Committee almost unanimously believes that the conclusions are absolutely true. The report is summed up in the form of conclusions, and perhaps we had better consider them in their order.

The Secretary:—"(1) Coal-tar creosote and zinc chloride are efficient preservatives when properly applied and when used under proper conditions.

"(2) It is necessary to keep better records than have been kept so far in order to form proper conclusions as to the merit of different methods and processes.

"(3) Preserved wood may be destroyed by mechanical action long before it is decayed.

"(4) The specification as given for coal-tar creosote is good practice and should be adopted."

Mr. W. W. Curtis (Consulting Engineer):—I want to call attention to one feature in connection with the specification for coal-tar creosote as referred to in conclusion 4. I regard the specification as an extremely good one, and one which, if adopted and lived up to, would give us a better article of creosote than we have generally had in past years. I have thought, however, before the Association adopts this standard, they should be advised of one or two matters in connection therewith.

Practically all of the records which we have of past treatments, and upon which we are basing our conclusions of the efficiency of creosoted material to-day, are based upon oil which would not meet the specification proposed for adoption. Of all the oil made in this country and in Great Britain, I think a comparatively small amount

would comply with the specification. The German oil would, and I am frank to say that I believe the German oil and the oil which would comply with the specification is a better article than we have had in past years, or that we are getting in many cases to-day, but that is very largely an assumption on my part. Another "but" is that we are confronted, and have been for the last five years, with the difficulty of not only getting the oil which we might want, but with getting any oil at all.

Now, in order to ascertain something about the actual conditions as they exist in this country, the Secretary of the Association was requested some months ago to send out a circular, which went to practically all of the timber-treating plants in the United States which were using oil, giving a short summation of the specification as proposed, and the firms were asked to state what proportion of the oil they had used during the two preceding years would meet the specification. I have here a statement showing these replies. There are three instances where the reply was that none of the oil which they had been using would be excluded under this specification. Of the other replies, five replied that 100 per cent. of all the oil they had been using would be excluded; another 98 per cent.; another 90 per cent., and so on down. Out of about twenty replies, there were three which reported that all of the oil they had received during the two preceding years would be covered by this specification, and the other seventeen reported that from 100 per cent. down to 5 per cent. would be excluded by the specification; five plants did not receive any oil which would comply with the proposed specification.

I wrote to a number—I think all—of the manufacturing plants in this country where creosote oil is made, asking them for a statement as to what percentage of their oil would be eliminated by this specification, and curiously enough I did not receive a single reply to my inquiry. That may be explained in two ways: either they are perfectly willing to comply with this specification, or they are indifferent as to what we specify and think we have to take their oil. As I said before, I agree fully with the conclusions that this specification, if adopted, will give us a better oil than we have generally had, but while I have no interest in it one way or the other, I doubt the wisdom at the present time of adopting a specification which will rule out a very large part of all of the American oil and which will also rule out a considerable part of the British oil, in view of the shortness of the supply.

Another matter I desire to refer to is that, immediately following the specification for coal-tar creosote, there is a specification for zinc chloride, which is printed in boldface type and is consequently intended for publication in the Manual. There is no conclusion reported by the Committee for the adoption of this. The Association already has in previous years adopted a specification for zinc chloride. In my

judgment it is a much better specification than the one now submitted, and consequently I want to call attention to the fact that the specification for zinc chloride is improperly printed in boldface type, if there is no intention to have it adopted; a specification for the same has already been adopted; and in my judgment the specification for zinc chloride as submitted is worthless; any kind of zinc chloride could be delivered under it.

Mr. A. L. Kuehn:—You will remember that I said the Committee was "almost unanimous"—unanimous, except one. I will answer for the remainder of the Committee why they voted to adopt the specifications for coal-tar creosote. There is a peculiar condition in this country governing the production of creosote oil. The supply is dependent entirely on the demand for pitch. In other words, creosote oil is not manufactured for the purpose of producing creosote oil only; that is, it is a by-product. The demand for pitch is limited to roofing, calking purposes, etc. The demand for creosote oil in America is much in excess of the production. Only about 30 per cent. of the creosote oil used in the United States is produced here, the rest is imported. An economic condition is involved in this. There is a demand for pitch in foreign countries greater than there is in the United States; one demand is for coal briquettes, which we do not use in the United States to any extent. The demand for pitch in Europe produces an overproduction of creosote oil. The creosote produced in this country being a by-product and there being a demand so much in excess of the production, makes the manufacturers of creosote oil peculiarly arbitrary, more so than the manufacturers of any other materials with whom we have to deal. They simply say, "there is the creosote, and if one does not take it, another will, without any regard to the quality."

The question of the preservative is so highly important that we cannot afford to take everything that is produced and spend money and time in attempting to bring about a long-life timber. No restriction has ever been placed on creosote oil. This specification, from Mr. Curtis' statement, might produce a hardship, yet we can get more oil in England to replace the oil that is being cut out in this country, and we can obtain oil similar to that used seventy-five years ago that preserved timbers from thirty-five to forty years. That is not very patriotic, to be sure, but a wholly economic condition is involved and being non-patriotic to that extent is warranted, because we are preserving our forests in doing it. The Association, in adopting this specification, is adopting a specification which is not rigid, not as rigid as it eventually will be, when we treat all of our timber with creosote, and we want to get now as good creosote oil as can be obtained—we do not want to take too many chances. Every time you do creosoting you are taking a chance, and we want to limit the taking of a chance to a minimum. I do not think there will be

any mistake made in adopting this comparatively lenient specification.

Mr. A. L. Kammerer (Rock Island-Frisco Lines):—The specification as it now stands is the result of considerable study and investigation. It is now generally conceded that the best practice in timber preservation calls for an oil that is comparatively free from low-boiling constituents. Mr. Curtis, in his remarks, stated that in his inquiry as to the number of plants whose oil would comply with this specification, of the total number only three stated that their oil would fall completely within this specification. It seems to me that it would be a much fairer way, rather than saying three of the total number, to express it in terms of gallons. The three particular plants he refers to represent almost one-half of the total oil consumption of this country. It may be difficult at present to obtain creosote oil in this country in accordance with this specification. The roads that I am connected with—Rock Island, Frisco, Chicago & Eastern Illinois and the Santa Fe—have no great difficulty in getting their supply of oil under specifications practically the same as this one. These four railroad companies consume, annually, about 20,000,000 gallons, representing a large portion of the oil consumption of this country.

In regard to the elimination of the low-boiling constituents of creosote oil in the specification, Messrs. Von Schrenk, Fulks and myself, in our laboratory at St. Louis, have conducted extensive experiments to ascertain whether or not these low-boiling constituents remain in the treated timbers after exposure. We have examined a great number of creosoted specimens, both in this country and in Europe, which have given service twenty-five years or more. The analysis of all the oils extracted from these samples shows a total absence of the low-boiling constituents, and the natural conclusion is that the long life of these old timbers is due to the presence of the heavy high-boiling constituents of the original oil which are at present found in them.

About two years ago we took an oil having the following analysis:

Specific gravity at 38 degrees C.				1.045
Fractions distilling below	210	to	235 degrees	23.3
" " "	235		270	24.1
" " "	270		315	17.5
" " "	315		355	17.1
Residue				15.5

A considerable portion of this oil was exposed in a vessel to the open air. After one year, it was found that 41½ per cent. had disappeared, 90 per cent. of which was the portion boiling below 235 degrees. Several ties were treated with this same oil and exposed to the weather for one year. The oil remaining was extracted and examined with the result that 25 per cent. was found to have disappeared. At about the same time we conducted another experiment to determine this disappearance of the low-boiling oils.

The American Telegraph & Telephone Company removed five telegraph poles from their lines in the neighborhood of Norfolk, Va., and sent them to our laboratory for examination. These poles were treated and placed in position in 1897. They had been in service about nine years when we examined them. The original oil with which they were treated was an oil very high in low-boiling constituents. It had 50 per cent. boiling below 235 degrees. Our examination of the oil extracted from these poles showed that 57.1 per cent. had disappeared from the tops and 35.5 per cent. from the butts.

These experiments conclusively prove that nearly all low-boiling oil is used in the treatment of timbers, and a very large per cent. of the portion boiling below 270 degrees disappears. The present specification was drawn up having these facts in mind. While it may appear somewhat rigid, and the American manufacturers may claim that they cannot live up to it, there is no doubt that with a little pressure the present American product can be made to closely approximate the requirements of this specification.

The President:—As Mr. Curtis cannot be here this afternoon, he desires to make a statement.

Mr. W. W. Curtis:—I persuaded the court to excuse me this morning from a hearing in which I was testifying, in order that I might be present here. Possibly some of you may misunderstand my position. I have absolutely no interest in the creosote business, either in buying or selling. I have simply called the attention of the Association to these conditions because I think you ought to know about them as a matter of information. I have no objection to the specification whatever as submitted. I see the possibility of some commercial difficulty for you if it is adopted. I hope to see that specification ultimately adopted, but my judgment is, it is not wise to adopt it this year.

(Afternoon session.)

The President:—The question is on the adoption of conclusion 4, relating to the specification for coal-tar creosote. The Secretary will read the specification.

The Secretary:—"Standard Specification for Coal-Tar Creosote.—The oil used shall be the best obtainable grade of coal-tar creosote; that is, it must be a pure product of coal-tar distillation and must be free from admixture of oils, other tars or substances foreign to pure coal tar; it must be completely liquid at thirty-eight (38) degrees Centigrade, and must be free from suspended matter; the specific gravity of the oil at thirty-eight (38) degrees Centigrade must be at least 1.03. When distilled according to the common method, that is, using an eight (8) ounce retort, asbestos covered, with standard thermometers, bulb one-half (½) in. above the surface of the oil, the creosote, calculated on the basis of the dry oil, shall give no distillate below two hundred (200) degrees Centigrade, not more than five (5) per cent. below two hundred and ten (210) degrees Centi-

grade, not more than twenty-five (25) per cent. below two hundred and thirty-five (235) degrees Centigrade, and the residue above three hundred and fifty-five (355) degrees Centrigrade, if it exceeds five (5) per cent. in quantity, must be soft. The oil shall not contain more than three (3) per cent. water."

Mr. Kuehn:—I move that the specifications be adopted.

Mr. W. F. Goltra (New York Central Lines):—The percentages which are given here are meaningless, unless the distilling vessel is more accurately described. "An eight-ounce retort" is an indefinite description and is interpreted variously by different dealers. Usually, it is understood to mean that the bulb part of the retort, when the latter is placed at proper angle for distillation, is to hold eight ounces of oil. These retorts vary in size, shape and especially in the size of the neck, so that it is difficult to obtain uniform results with different kinds of "eight-ounce retorts." The influence of the vessel on the fractional distillation of creosote is very great. Oil that would meet this specification when analyzed with an eight-ounce retort, would not, in most instances, fulfill the specifications if analyzed with the Hempel distilling flask, or three-bulb Ladenburg flask. It is true that a much more accurate analysis can be obtained with either of these two instruments than with the eight-ounce retort, but it involves a great deal more work. Analysis made with the eight-ounce retort is more simple and perhaps better adapted to plant operations, where a fine laboratory test is not required. The use of eight-ounce retorts was suggested by the tar distillers, because it is used by them to make rough tests at the works. We should have a more definite description of the distilling vessel and other apparatus used in making analysis of creosote oil.

I desire to raise another question. It is my opinion that these specifications are too rigid. Very little of the creosote oil manufactured in this country would fulfill this specification, so far as the percentages of light oil or naphthalene is concerned. It is claimed that the light oil evaporates and leaves no resultant in the tie. Therefore, the smaller the percentage of light oil the better, and it is proposed that not exceeding 25 per cent. distillate will be given off below 235 degrees Centigrade. Most of the oil which I have come across contains more light oil than allowed by the proposed specification. The more we restrict the percentage of light oil the higher will be the prices, as it curtails the available supply. Our specifications should conform to nearly what is produced and sold on the American market, and not attempt to make the oil fit our specification, but rather make our specification fit the oil. We can make a shoe fit the foot, but we cannot make a foot fit the shoe. In brief, I think our specification should be changed so as to read, "not more than 30 per cent. below 235 degrees Centigrade," instead of 25 per cent. This would more nearly fit the oil that we find on the market, and if our specification

is too rigid it will exclude a great part of the supply, consequently increasing the cost of oil correspondingly.

Mr. A. L. Kuehn:—The standard method and description of apparatus was adopted last year, which can be seen by reference to the report, or to the Manual. The specifications are not too rigid; the gentleman is mistaken. The whole question is a question of economics. Granting that the price of creosote oil was increased by such a specification, the cost would be more than made up by the increased life of the timber. I know of cases where timber has been treated with creosote oil where 50 to 60 per cent. of the creosote has disappeared within a year. That kind of creosote we certainly do not want to use.

Mr. Goltra:—I would like to ask Mr. Kuehn how he knows, or on what he based his statement, that oil which has evaporated has not left any good results in the tie?

Mr. A. L. Kuehn:—I do not know; but may I ask, in return, how you know that it has?

Mr. Goltra:—We do not know to a certainty. It is possible to believe that the oil which has volatilized from the timber has created an antiseptic environment, which has been a potent factor in preserving the wood.

Mr. A. L. Kuehn:—You made the statement that you might want a light oil. I have more ground for saying that the light oil has not done any good than you have for saying that it has, because the light oil actually disappears, and timber which has been treated with heavy oil has given the best results. The light portion of the oil is the naphthalene, very volatile, and is that portion which disappears. There is another answer that I can make to the query of the gentleman, that is, that the seventeen members of this Committee, among whom are men who have had the longest experience with creosoted timber in the United States, and one of whom is thoroughly conversant with European results, agree that we want heavy creosote.

Mr. E. H. Bowser (Illinois Central):—This specification is certainly a very fine specification for oil, but several railroads I know of are getting oil with a distillation of 30 per cent. at 235 degrees; and I do not think 5 per cent. added to the specification prepared by the Committee will cut much figure. In most of our oil we do not get a distillation of more than 25 per cent.; more often it comes several degrees under. In the older specifications for oil it was almost invariably the custom to allow 45 per cent. of naphthalene in the oil. That would mean 50 to 55 per cent. of distillation up to 235 degrees. I know the Louisville & Nashville specifications at one time allowed as much as 75 per cent. I do not think we ought to make such an extreme jump in the change of specifications for oil. I believe it ought to be changed to 30 per cent. In most cases we will get below it.

Mr. Goltra:—I agree with the last speaker, that we ought to add to this specification a clause permitting the allowance of five points variation in the percentages so that oil will pass under specifications that require not exceeding 35 per cent. distillate passing off at 235 degrees.

Mr. Bowser:—I move that the specification be changed to read, "30 per cent. of oil distilled up to 235 degrees Centigrade," instead of 25 per cent.

Mr. L. C. Fritch (Illinois Central):—I would like to ask the Committee how much difference in price this would make in the cost of creosote oil?

Mr. A. L. Kuehn:—I am not able to answer that definitely, but I am of the firm belief it will not make any difference.

(Mr. Bowser's motion was lost.)

The President:—The question is now upon the specification as given in the report.

(Motion to adopt the specification carried.)

The Secretary:—"(5) There should be a standard temperature at which coal-tar creosote is measured. The temperature of 100 degrees Fahrenheit as given in the report is recommended.

"(6) It is essential that timber should be properly grouped in order that a successful treatment may be obtained. The species, proportion of heartwood and sapwood, condition of the timber with respect to its moisture content, and the wood structure, will in general determine this grouping.

"(7) It is desirable to air-season timber in order to prepare it for treatment. Most woods can best be treated after being air-seasoned."

Mr. A. L. Kuehn:—I move the adoption of the conclusions of the Committee as a whole.

Mr. L. C. Fritch:—I second the motion.

(Motion carried.)

The President:—The Committee on Wood Preservation will be relieved, with the thanks of the Association.

REPORT OF COMMITTEE NO. II—ON BALLASTING.

(Bulletin 107.)

To the Members of the American Railway Engineering and Maintenance of Way Association

Your Committee on Ballasting begs to submit the following report:

Two meetings were held at the Association rooms in Chicago, the first on September 11, 1908, Messrs. John V. Hanna, C. A. Paquette, F. J. Stimson, A. W. Thompson and W. Beahan being present, and the second on November 13, 1908, at which Messrs. John V. Hanna, C. A. Paquette, F. J. Stimson, G. D. Hicks, W. Beahan and W. J. Bergen were present.

At the meeting of September 11, sub-committees were appointed for the purpose of gathering data and preparing a report on customary recommended practice for preparation and delivery of various kinds of ballast; also advantages and disadvantages of various types of ballast. These sub-committees were as follows:

Sub-Committee A—*Crushed Rock:* A. W. Thompson, Chairman; J. B. Dickson, C. A. Paquette.

Sub-Committee B—*Slag:* B. C. Milner.

Sub-Committee C—*Gravel (Bank and Washed):* F. J. Stimson, Chairman; W. Beahan, W. J. Bergen, C. A. Paquette, H. O. Garman.

Sub-Committee D—*Chats:* G. M. Walker, Jr., Chairman; A. F. Rust, H. E. Hale.

Sub-Committee E—*Cementing Gravel and Chert:* G. D. Hicks.

Sub-Committee F—*Disintegrated Granite:* W. C. Smith.

At the meeting held November 13, Sub-Committees A, C, D and E reported, and the report of the General Committee, as here presented, is principally their work.

The Committee's previous report (see Proceedings, Vol. 9, p. 307) was confined to consideration of a revised section for crushed rock ballast, the Committee's recommendation being adopted by the convention (see Proceedings, Vol. 9, p. 312).

The Committee at this time wishes to submit new definitions for gravel and sand, to take the place of those heretofore recommended and published in the Manual (see 1907 Edition, p. 39).

Primarily it occurs to your Committee that a more specific definition is necessary. When it comes to the execution of contracts for washed or screened gravel, or the erection of a company plant for that purpose, the sizes of the particles to be retained or rejected are matters of importance, and it is certainly desirable to have some definite standard as a guide. Your Committee considers that it comes within its

province to suggest and recommend such standards so far as ballasting practice is concerned, and, in order to do so, wishes to cover it by definitions.

The definitions adopted state that gravel is coarser than sand and that sand is finer than gravel, but fail to establish any limit of size, below which worn fragments of rock cease to be gravel and become sand. This limit, of necessity, is an arbitrary one and probably will vary with the use to which the material is to be put. To the end of determining a definite demarcation between gravel and sand, when used as ballast, material from a number of pits was passed through screens with meshes of various sizes. It was found that all the particles retained on a No. 10 screen were of a size that could not be reasonably termed sand. It was also found that of the material which passed a No. 10 screen, all which was retained on a No. 50 screen was coarse enough to be termed sand, while anything which passed the No. 50 screen was so fine as to be merely dust.

Therefore your Committee recommends the substitution of the following definitions:

GRAVEL.—Small worn fragments of rock occurring in natural deposits that will pass through a 2½-in. ring and be retained upon a No. 10 screen.

*SAND.—Any hard granular comminuted rock material, finer than gravel, which will be retained upon a No. 50 screen.

PREPARATION AND DELIVERY OF BALLAST.

CRUSHED ROCK.

Your Committee was at first in some doubt as to the best way to present this part of the general subject of ballasting, but concluded that it could best be done by describing some actual plants that seemed to be examples of good practice. The Hog Mountain plant of the Lackawanna, description of which has been furnished by Mr. Lincoln Bush, Chief Engineer of that road, has seemed to the Committee such an example:

"Early in 1905 our company acquired by purchase near Boonton, N. J., a granite quarry and crusher plant, together with other equipment in the way of cars, machinery, etc., that were utilized by a contractor in connection with the construction of a large masonry dam for a reservoir. This work having been completed by the contractor, the Lackawanna Railroad Company acquired about three miles of railroad running from its main line to the quarry plant, together with about fifty-six acres of ground, tracks at crusher plant, etc. In adapting this plant to our use and rearranging the tracks and crusher layout to meet our requirements, we expended at the outstart $21,904.33,

*Amend definition to read: "Sand.—Any hard granular comminuted rock material which will pass through a No. 10 screen and be retained upon a No. 50 screen."

and sold from the contractor's outfit certain equipment not required by us, which sale netted us $18,159.31, making the net cost to us of the quarry and plant at the time we started operating the crusher $26,245.02.

"The material obtained from this crusher plant is a very good quality of New Jersey granite, weighing 2,795 lbs. to the cubie yard of crushed stone.

"The quarry was well opened up when we acquired it from the contractor, and the face of the quarry has a depth of from 20 to 60 ft. and a length of about 2,200 ft. The stripping on top of the quarry will average about 2½ ft. The crusher machinery was manufactured by the Allis-Chalmers Company, and consists of one No. 8 and one No. 6 crusher, with a large bucket conveyor for conveying the broken stone from the crusher to the screens. There is one large 48-in. diameter screen, consisting of three sections, each 4 ft. in length, with ringings from ½-in. to 2½ in. in diameter and a dust jacket for separating the materials. Materials which pass through the ½-in. ringing are not used for track ballast. The ballast product is conveyed on a Robbins Belt Conveyor and deposited into a system of bins; the finer material and dust pass directly over the dust jacket into the dust bin. The percentage of fine materials, i. e., dust and ¼-in. stuff, runs from 12 per cent. to 14 per cent. of the total output. The grades of tracks at the crusher plant are so arranged as to handle the cars after being placed by gravity. There is a powder magazine located on the property which has a storage capacity for about ten tons of powder and explosives. There is also a water system for the boilers and a sprinkling plant to keep down the dust. The maximum grade of the track connecting our main line with the quarry is 3 per cent. ascending to the quarry, and in handling our ballast we have been utilizing a locomotive which will handle fourteen empty Rodger ballast cars up this 3 per cent. grade. The larger part of the stone is handled from the quarry to the crusher plant by means of a derrick system, the face of the quarry being located quite close to the crusher plant. We have in use six large derricks with 90-ft. masts, which, with six hoisting engines operated in connection with the derrick system, handle the stone in large stone boxes. The stone is quarried from the top of the face by a stepping system. To pass into the No. 6 crusher the stone has to be broken up in sizes from 16 in. to 20 in. The breaking of the material is done with a system of block hole drills, placing holes from 6 in. to 12 in. apart, depending upon the size of the stone to be broken. We use from three to six block hole drills per day in breaking up the larger stone and some of the smaller stones are sledged instead of being block holed. In addition to the derrick system at this plant we also have a car system, by means of which cars loaded with stone from the quarry are dropped by gravity to the crusher. These cars have from 12 to 16 yards capacity, and when the

cars reach the crusher plants are dumped by one of the derricks. The bottom of these cars is constructed of wood and metal, with a chain attached, and the false bottom of the car is picked up on one end by the derrick, and the stone dumped by this means without manual handling. After the cars have been dumped at the crusher they are returned to the quarry by a haulage system, operated by a hoisting engine. The stripping from the top of the quarry is disposed of by piling it back from the face of the quarry. In operating the quarry and crusher we have employed an average of 125 men, including rock men, drill men, engineers, mechanical men and laborers required at the quarry and crusher. We employ two blacksmiths for handling the drill work and a pipefitter for taking care of the steam-pipe system and steam drills. One mechanical foreman with the necessary help has charge of the crushing plant and one general foreman has charge of the quarry. One engineer handles the engine in the crusher plant and one fireman does the firing. We also utilize a 150-H.P. boiler for generating steam for the drills, and in addition to this we have two 150-H.P. boilers for furnishing the balance of power for the derricks and at the crushers.

"We started operating the quarry and crusher plant in May, 1905, and I am enclosing detailed monthly statements of the cost of operations at this plant from May, 1905, to August, 1906, both inclusive. (See tabulated statement on page 682.) The plant was shut down on January 15, 1906, and operations resumed in March, 1906. The detailed statements of the cost of quarrying and crushing stone at this plant have been carefully kept and are reliable as to the cost as well as the output. The cost includes the quarrying and crushing, and includes the material loaded on cars at the bins.

"The tabulated statement on page 682 shows the total output from May, 1905, to August, 1906, inclusive, together with the average cost of quarrying and crushing, including the materials loaded on cars for the period noted.

"We have used the crushed stone from this plant at various points along our line on the Morris and Essex Divisions, and during the present season we put on a ballast gang for ballasting a 4½-mile section of double track located between Hopatcong and Wharton, N. J.

"In handling the ballast on this 4½-mile section we had an average of 31 laborers at 14 cents per hour per day of 10 hours and one foreman at $75 per month. In addition to the regular ballast gang we had eight section laborers on the 4½-mile section that were employed in digging out, changing ties, placing drain tile and filling for changes in alinement and easement curves. The amount of ballast used on the 4½-mile section of double track was 28,458 yds., or an average of 6,324 yds. per mile of double track. The average distance which the ballast was hauled from the crusher to the section ballasted was thirteen miles. On the 4½-mile section of track ballasted there was a total length of curve line of 1.56 miles and a total length of

tangent of 2.94 miles. We used in this work 24 Rodger ballast cars, and in figuring the cost of transportation the cars were placed at a value of $600 each. Our records show a cost of 5½ cents per yard, covering transportation charges, interest on the Rodger ballast cars valued at $600 each at 5 per cent., plus interest at 5 per cent. on the net investment of the quarry and crusher plant. The cost for quarrying, crushing and loading cars at the crushing plant was 55 cents per yard; the cost of placing ballast under track, including lining, surfacing and dressing, was 20½ cents per yard, making a total cost per yard of the ballast in the track of 81 cents for the 4½-mile section above described.

"On the west end of our Buffalo Division we have an accurate record of the cost of 27,120 yds. of crushed limestone ballast put in on a stretch of double track during the season of 1906. For this work we purchased the crushed stone delivered to us in our own Rodger ballast cars at an average cost of $0.6017 per cu. yd., and received an average of 222 cu. yds. per day, the quarry being located on our own lines. Thirty Rodger ballast cars were used for this work and the average haul was 13.4 miles. The ringing used in preparing this ballast was from ¾-in. to 2½-in. diameter and the stone weighed 2,410 lbs. to the yard. As above stated, we received on an average 222 cu. yds. per day, and a larger quantity per day would have reduced the cost per yard somewhat. In comparing this cost with the cost of ballasting with materials obtained from the Boonton crusher plant, it will be noted that the ballast on cars from the Boonton plant cost practically five cents per yard less than the material used on the Buffalo Division. The work on the Buffalo Division cost a total of 88.1 cents per yard in track, which cost included the material, engine service, labor, tie renewals, and spacing, and interest on ballast car equipment."

The plant just described is on a sufficiently large scale for continuous, economical working, which the Committee considers good practice when conditions justify it. The quantity of ballast to be used, whether limited by requirements of the track itself, or by financial considerations, may be so small that a large plant would be extravagant. Such a condition must be met by a plant designed to fit the case, in which local features would cut a large figure. After some discussion your Committee decided that descriptions of small plants would not be sufficiently valuable to justify the space occupied and they are therefore omitted.

PIT GRAVEL.

The procedure in preparing gravel for ballast varies with the nature of the pit and the use to be made of the ballast. If a pit from which ballast is to be taken is submerged, obviously no stripping is necessary. If it is an upland pit, however, it is rarely wise to omit the removal of enough surface dirt to leave only material as good as the pit will furnish.

HOG MOUNTAIN CRUSHER—DELAWARE, LACKAWANNA & WESTERN RAILROAD COMPANY.

Month and Year	Quarrying Stone				Crushing Stone				Cost per Yard Quarrying and Crushing	Additional Expense at Plant—Labor, Placing Derricks, Etc.	Total Cost	Total Cost per Yard	Average No. Yards per Day
	Labor	Supplies	Output	Cost per Yard for Quarrying	Labor	Supplies	Output	Cost per Yard for Crushing					
May, 1905	$2,869.54	196.73	6637	46.2	$368.55	$226.00	6637	8.9	55.1	$1,068.10	$4,728.92	72	246
June, 1905	3,338.65	229.02	7048	50.6	377.40	157.97	7048	7.6	58.2	741.30	4,844.34	69	271
July, 1905	3,128.65	374.75	6267	55.9	317.18	94.25	6267	6.6	62.5	384.34	4,299.17	59	241
August, 1905	4,029.45	429.63	8722	51.1	368.55	94.25	8722	5.3	56.4	230.17	5,152.05	59	323
Sept., 1905	3,403.40	470.15	7017	55.2	361.70	104.25	7017	6.6	61.8	143.57	4,483.07	63	270
October, 1905	3,149.03	388.88	6321	56	359.40	94.50	6321	7.2	63.2	168.35	4,160.16	66	243
November, 1905	2,988.76	338.58	6219	47.9	266.64	94.50	6219	5.8	65.1	116.00	3,945.98	67	235
December, 1905	2,638.77	395.55	5882	57.5	351.17	94.50	5882	7.6	53.7	....	3,338.49	53	249
January, 1906	1,119.80	146.13	3233	39.2	150.26	52.35	3233	6.3	45.5	....	1,467.54	45	269
April, 1906	3,339.96	534.42	7516	51.5	315.00	185.72	7516	6.7	66	592.46	4,967.56	66	301
May, 1906	3,958.95	657.98	11594	40	393.73	177.54	11594	5	50	573.85	5,763.05	50	429
June, 1906	4,157.54	806.95	10622	47	355.00	212.45	10622	5	52	....	5,527.94	52	409
July, 1906	4,178.91	783.78	10894	45.5	374.18	261.01	10894	6	52.5	....	5,597.88	52	436
August, 1906	4,335.26	681.47	10183	49	379.68	236.41	10183	6	55	....	5,632.82	55	377

Total average cost for quarrying, 49.04 cents per cubic yard.
Total average cost for crushing, 6.47 cents per cubic yard.
Total average cost per cubic yard, 55.51 cents.
Plant not in operation in February and March, 1906.

When the conditions require gravel to be washed or screened it will still be found wise to strip most upland pits, as the surface dirt will interfere with the proper gradation of the material.

Stripping.—In general, the best method for removing the waste material is to use a steam shovel, loading the material into cars and using it to widen embankments. When the depth of stripping is too shallow to permit the economical use of a steam shovel, teams with scrapers can be used to windrow the strippings, using a steam shovel to load the windrows.

The cost of stripping a gravel pit with a steam shovel, using the material to widen embankments, when the haul does not exceed twenty miles, should not be more than fifteen cents per yard.

Loading.—A heavy steam shovel with a dipper holding from 2½ to 3½ yds. makes a most efficient machine for loading gravel. Too great stress cannot be laid upon the advisability of having a shovel which has a large surplus of strength in all its parts, as economy in maintenance and in the operation, resulting from lessening the loss of time occasioned by stopping for repairs, is very great. Center dump cars, which deposit the material where it can be used without any casting with shovels, are most economical, the larger the capacity of the cars the better.

In connection with the center dump cars, ballast spreaders mounted under a flat car are a necessity. The practice of placing a tie or like obstacle in front of the wheels, allowing them to skid while the ballast is being pushed out of the way, is a bad practice, resulting in flat wheels, as well as loss of time in distribution of the ballast. Where only a small amount of ballast is to be handled, a device which will be mounted by the wheels and will itself slide on the rails can be used to good advantage.

Where only a very small lift or none at all is to be made, a great saving in time of applying the ballast can be made by the use of a distributing plow, which plows out the ballast close to the tops of the ties.

In most cases it will be found best to organize a crew at the pit in charge of an able, experienced conductor, who will do all of the spotting of cars at the shovel, and, to a certain extent, take charge of the movement of the other trains in the gravel service to the various distributing points.

Cost.—It is impractical to give any approximation of the cost of preparing the gravel pit for operation, as local conditions will govern this entirely. The cost of loading the gravel depends upon three conditions:

(1) The size and efficiency of the shovel.

(2) The depth of the bank from which gravel is being loaded.

(3) The supply of cars maintained under the shovel dipper.

As before stated, a shovel with a dipper having a capacity of 2½ to 3½ yds. and designed with a large surplus of strength in all its

parts makes a very efficient loading machine. Where the bank is 10 ft. or more in depth the greatest efficiency of the shovel should be obtained. Not less than four pitmen should be used, that no time may be lost in shifting. Where the bank is less than 10 ft. in depth it will generally be found that the frequent shifting of the shovel will materially reduce the output of gravel. It is assumed that the train service is sufficient to keep the shovel supplied with cars in order to make use of its full efficiency.

With the above conditions obtaining, from 2,000 to 2,500 cu. yds. per day on an average can be handled, the cost of which will be approximately $0.025 per yard based on the following rates of pay:

1 Train Engineman	$ 4.85
1 Train Fireman	2.75
1 Conductor	4.85
2 Brakemen	7.00
1 Shovel Engineer	4.80
1 Shovel Fireman	2.70
1 Cranesman	3.45
1 Watchman	2.10
4 Pitmen	7.00
Fuel, Oil and Waste—Train and Shovel	13.80
Total	$53.30

Distribution.—The length of haul regulates entirely the question of the number of trains and the number of cars to a train which should be used. The one hard and fast rule should be that the best of motive power be furnished for this service. Generally speaking, for hauls less than ten miles, one train in addition to the train at the pit is sufficient. Above ten miles and under thirty, two trains on the road will be sufficient. The only rule that can be stated is that, to get the most economical handling of ballast, to provide train service enough to keep the shovel well supplied with empties at all times. Where the haul is short the best practice is to put into one train only so many cars as can be handled readily by the engines which are assigned to that service. There is a decided loss on short-haul work where more cars are put into a train than can be dumped without difficulty by the engine.

When the haul is long all the cars should be given to a train that can be moved over the division, and enough set off on the siding nearest the distributing point to reduce the train to such size that the engine can readily handle it while dumping. This applies to center dump cars, where the movement of the train when being unloaded is very much harder than when on the road. In some cases it will be found economical to provide a train for the purpose of taking the loaded cars at the end of a long haul and unload them. It frequently happens that unforeseen delays occur during the unloading which

will seriously cripple the through movement of the gravel trains, and on very long hauls the unloading train can be economically employed.

The cost of movement from the pit and distributing on the track depends wholly upon the length of the haul and congestion of traffic. The actual time consumed in distribution with center dump cars is immaterial, 30 minutes being sufficient time for the unloading of a train of from 400 to 500 cu. yds.

WASHED OR SCREENED GRAVEL.

The essential features of a plant for this purpose are:

(1) Positive separation of material into definite grades.

(2) Capacity to furnish gravel in quantities sufficient for economical use as ballast.

(3) Economical operation.

(4) Economical disposition of the refuse, both boulders and fine material.

To fulfill the first requirement a plant must be so designed as to separate the material handled into dust, sand, gravel and cobbles or boulders. If these grades are not separated the proper proportion of sand and gravel necessary for the best results cannot be obtained.

In distributing ballast on track it is obviously necessary to produce the gravel in large enough quantities to permit the organization of the track forces on an economical basis. A plant which will produce gravel at a cost which would make it commercially profitable may be too small to produce ballast economically.

That the screening plant must produce the gravel economically is obvious.

In the preparation of quantities of ballast there is necessarily produced a large amount of mud, sand and boulders or cobbles. To work successfully a plant must be so devised as to dispose of this rejected material. The stones should be run through a crusher and returned to the gravel for ballast, not only increasing the output, but improving the quality.

Plants for the washing or screening of gravel naturally divide into two types:

(1) Those for handling material from submerged beds of gravel.

(2) Those for handling material from upland gravel banks.

The plant of the Union Sand & Material Company, South Memphis, Tenn., is a typical submerged gravel-bed washer, and the Lake Shore & Michigan Southern plant at Pleasant Lake is typical of the upland washer.

DESCRIPTION OF UNION SAND & MATERIAL COMPANY'S PLANT.

The equipment used to get this gravel from the river is a fleet of one tug and six barges, with a capacity of between 250 and 300 cu. yds. each; one dredge, with two 15-in. centrifugal pumps, each equipped with a length of pipe varying from 30 ft. to 75 ft., depending upon the depth of the water. These suction pipes can be moved

horizontally and raised and lowered by means of a derrick with boom extending out from the front of the dredge. The two centrifugal pumps can load a barge in about one hour and ten minutes, and, as the average distance traversed from the barge to the plant is about 1½ miles, the tug is kept busy transporting the loaded and empty barges. Figs. 1 and 2 show dredge in operation loading into barges. Fig. 3 shows a view of the washing plant and Fig. 4 shows a section of a typical plant.

The machinery on this barge was furnished by the Morless Machine Company of Baldwinsville, N. Y. The dredge is about 130 ft. long, 30 ft. wide and heavy construction. The barges are 130 ft. by 30 ft. over all.

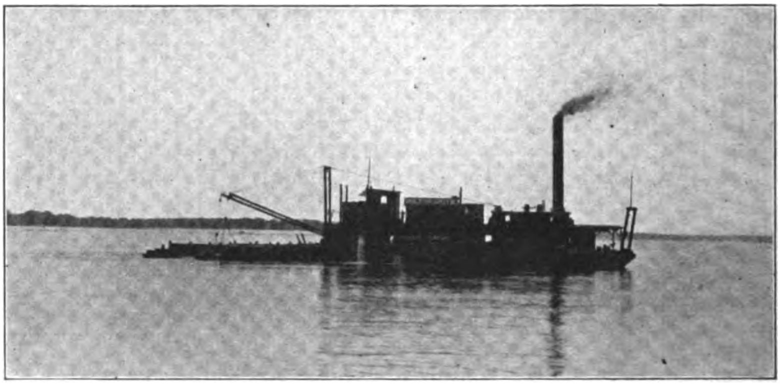


FIG. 1. DREDGE IN OPERATION LOADING GRAVEL INTO BARGES.

Second.—The plant consists of two boilers, furnishing steam to an engine with 12½x16-in. cylinders. This engine furnishes power for running the plant, as well as pumping water to wash the gravel, of which about 1,500 gallons per minute is used.

The plant proper is built up on a network of creosoted piles, driven down well into the bank of the river. These piles are all cut off at the same elevation and have cribbing placed on top of them, upon which the plant has been erected. On the river side of the plant, where the four-leg tower has been erected, which supports the overhead carrier, there have been four clusters of piles driven under each leg. This overhead carrier hangs at an angle of about 30 degrees from the horizontal, the river end being the lower. At each end of this carrier there are a number of pulleys, upon which are operated the wire cables to handle the 5-yd. clamshell bucket.

The type of engine used to operate this clamshell bucket is the regular four-drum Lidgerwood. One man operates all the machinery connected with this bucket.

The river end of the overhead trolley system extends out sufficiently from the river to enable the clamshell to be lowered directly over the barge after it has been placed in front of the plant of the tug.

The overhead trolley system is placed at right angles to the river and the sand and gravel is transported to the bins by simply raising the clamshell until it comes in contact with the hook in the overhead trolley system. As soon as the contact is made with this hook, motion away from the river is commenced and the material in the bucket can be dumped at any point desired along the entire length of the overhead trolley, this being at the command of the engineer.

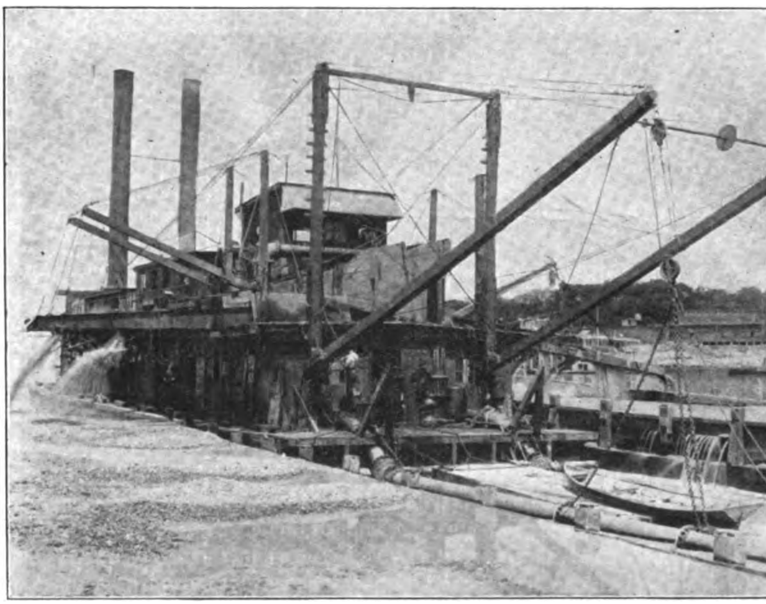


Fig. 2. Dredge in Operation Loading Gravel into Barges.

Third.—On the land side of the tower supporting the overhead trolley are built the bins for the receiving, washing and storing of the various kinds of sand and gravel acquired.

The gravel is dumped about halfway on the overhead trolley into a large hopper. At the bottom of this hopper is a gate; directly under the gate is a belt conveyor, which operates over concave rollers. In the concave belt is dropped the gravel by means of the gate. This conveyor runs at an angle of about 45 degrees to the overhead trolley, and at its end is another hopper smaller than the first one, but worked in the same manner, over which all of the gravel is carried to a second belt conveyor of the same character as the first, which operates at

right angles to the first conveyor and deposits the gravel as it comes from the barge into the chute, where the water is turned on the sand and gravel for the first time.

The gravel then is washed down various chutes and sluiceways and over different mesh screens to separate the finer gravel. As the gravel is separated by this different mesh screening, it is carried through by means of sluice boxes to the proper bin, and there deposited ready to be loaded into the cars at any time. This is done by simply opening the gates placed in the bottom of the bins, which are built sufficiently long and with a sufficient number of gates to load an average length car at one spotting. Figs. 3 and 4 show the arrangement of these screens, sluiceways and bins.

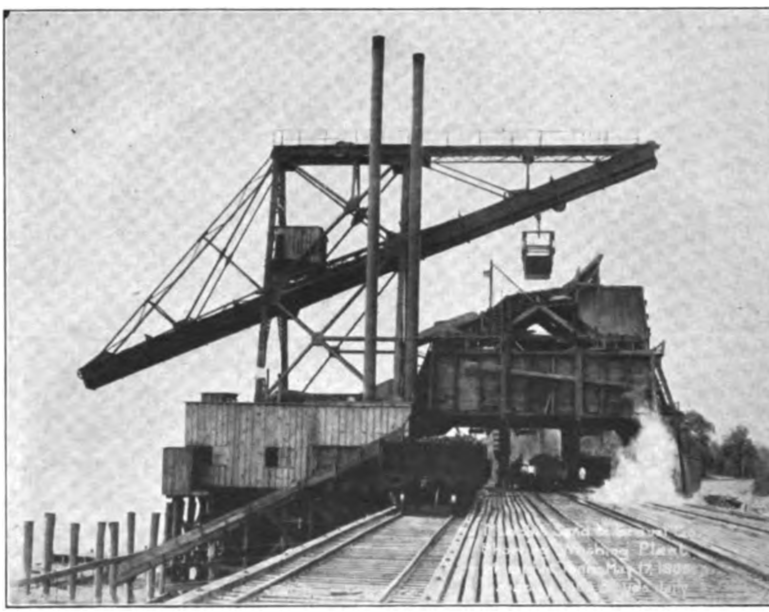


FIG. 3: VIEW OF GRAVEL WASHING PLANT.

The waste water carrying the sand goes through a large box, which has an outlet near the top. This box has a movable bottom and as the sand goes into the box it is dumped directly into the bin.

The gravel turned out may contain any required amount of sand. That is, one kind of gravel used for roofing purposes is entirely free from sand and is supposed to go through a screen that has a mesh of $\frac{5}{8}$-in. to $\frac{1}{4}$-in.

The gravel that goes through a screen from 1 in. to ¼-in. is called binder gravel, and is used for building purposes, where a clean gravel is required.

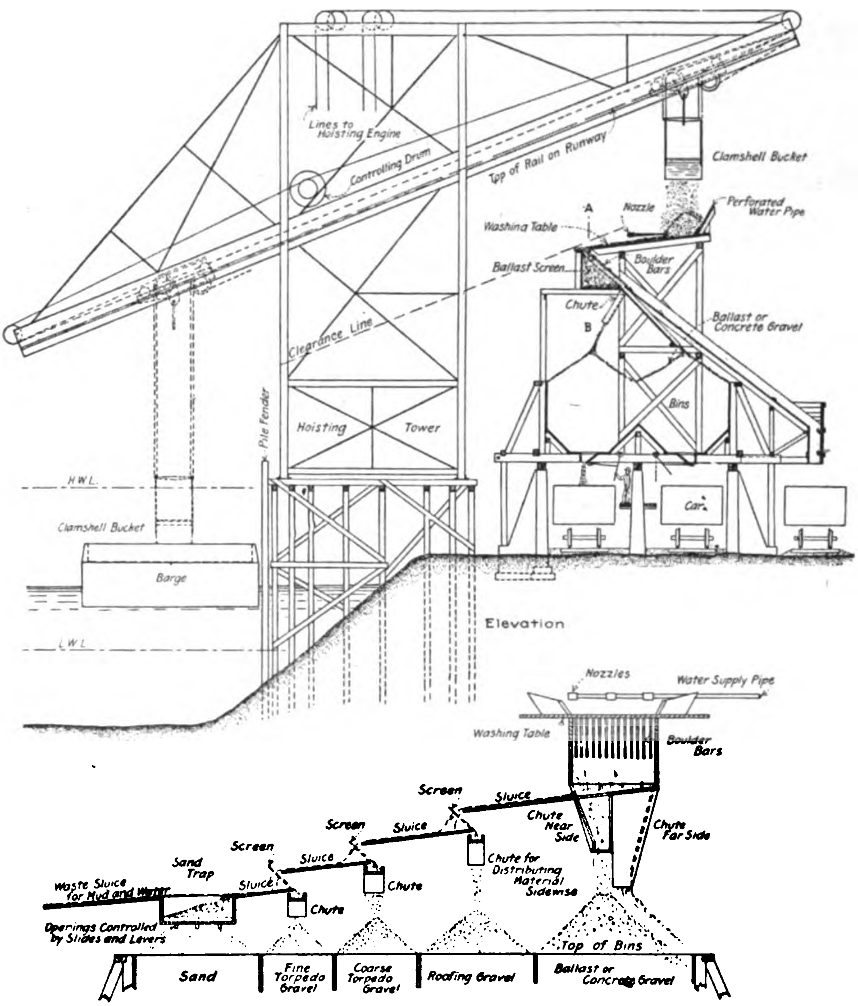


FIG. 4. TYPICAL GRAVEL HANDLING PLANT.

The gravel furnished for concrete purposes, where it has not been washed, usually contains from 25 to 45 per cent. of sand, depending upon the order given.

The gravel furnished the railroad company for ballasting tracks contains from 25 to 35 per cent. sand and is free from all large rocks or foreign material.

The track facilities consist of three parallel tracks, each of which extends sufficiently far beyond the bin to hold six cars. If only one kind of gravel is being loaded at a time, the tracks are of sufficient length to enable 30 cars to be loaded, but it is necessary for the switch engine to make a shift of cars.

The plant is operated by a superintendent, first and second engineer, blacksmith and helper, timekeeper and various help needed around the plant and on the barges. This force is exclusive of the forces employed on the tug and on the dredge.

The tracks, before they reach the plant, have been built up on a pile trestle for a distance of about 200 ft. In fact, all the tracks around the plant proper are supported by creosoted pile trestles.

On the river side of the plant there has been a pile breakwater built to protect the plant from the drift coming down at a high stage of the river.

The plant, designed by Brenneke & Fay, of St. Louis, cost, ready for business, approximately $140,000, and the life of it is expected to be 15 years.

The maintenance per year is figured at from 2 to 5 per cent. of the first cost, the yearly maintenance varying largely on account of the varying conditions, as it cannot be calculated just what machinery will have to be replaced during the year.

Under favorable circumstances the capacity is from 2,000 to 2,500 cu. yds. of gravel per day of 12 hours. A barge of 250 cu. yds. or 300 cu. yds. can be unloaded in from 50 minutes to one hour.

The daily output of the plant is dependent upon good working conditions at the barge, good condition of machinery at the plant, and the switching facilities. An engine is constantly kept at the plant for switching, and the material is loaded into any kind of gravel or ballast cars.

PLEASANT LAKE PLANT OF THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

This company erected a plant in 1905 operated by electricity, located at Rupel, a few miles south of South Bend, Ind. The company put up another plant in 1906 at Pleasant Lake, a short distance north of Waterloo, Ind. This plant is operated by steam. As this form of motive power is more general in availability, it is the one illustrated in this report. As the Rupel plant was the pioneer, the Pleasant Lake plant had the benefit of the experience gained there.

The gravel from the pit at Pleasant Lake is a fine gravel, mixed with much sand, some stone and boulders and a minimum amount of clay and loam. The object in washing the pit-run gravel is to remove all the clay and loam, to crush the stone and boulders for ballast

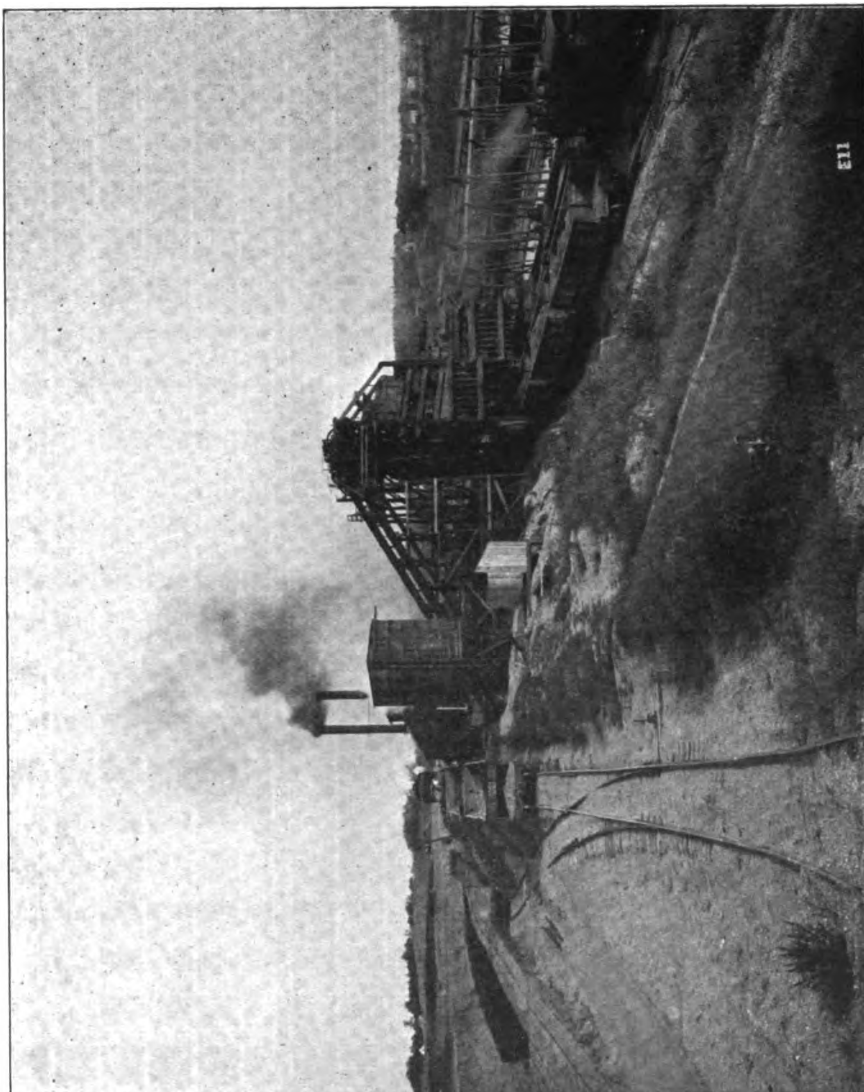


Fig. 5. Pleasant Lake Plant, Lake Shore & Michigan Southern Railway.

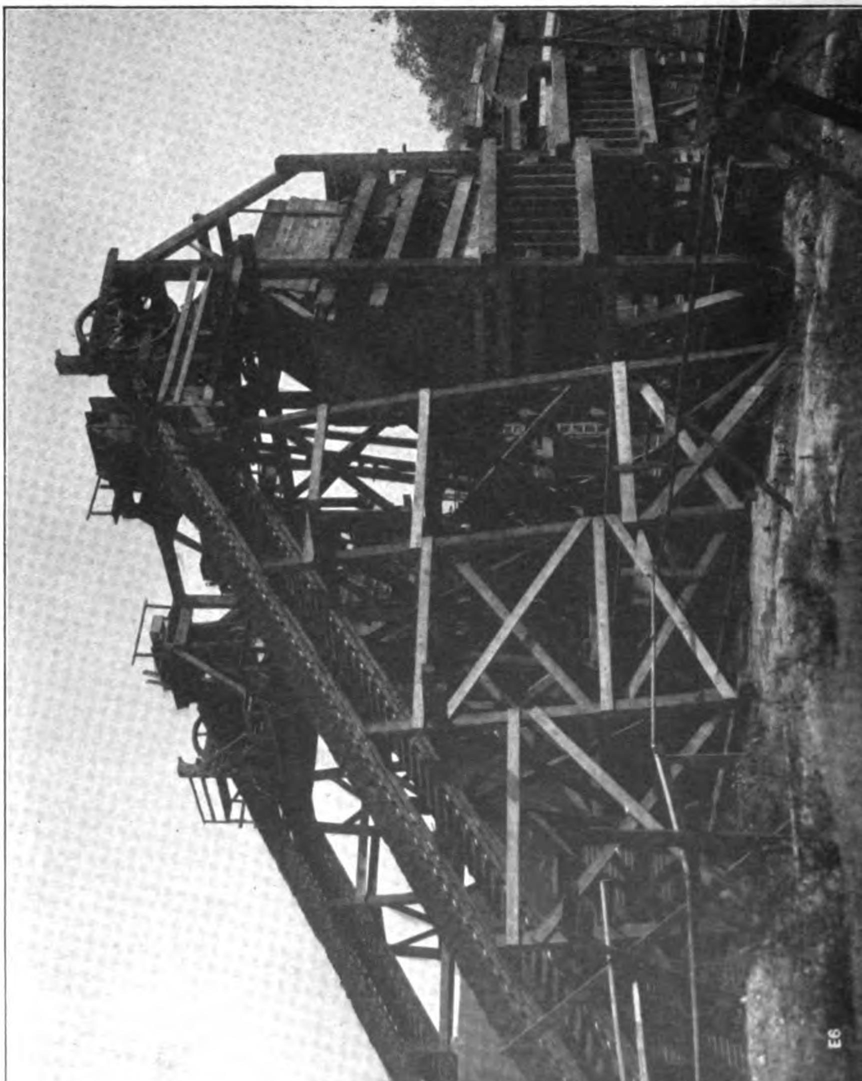


FIG. 6. CONVEYORS OF PLEASANT LAKE PLANT, LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

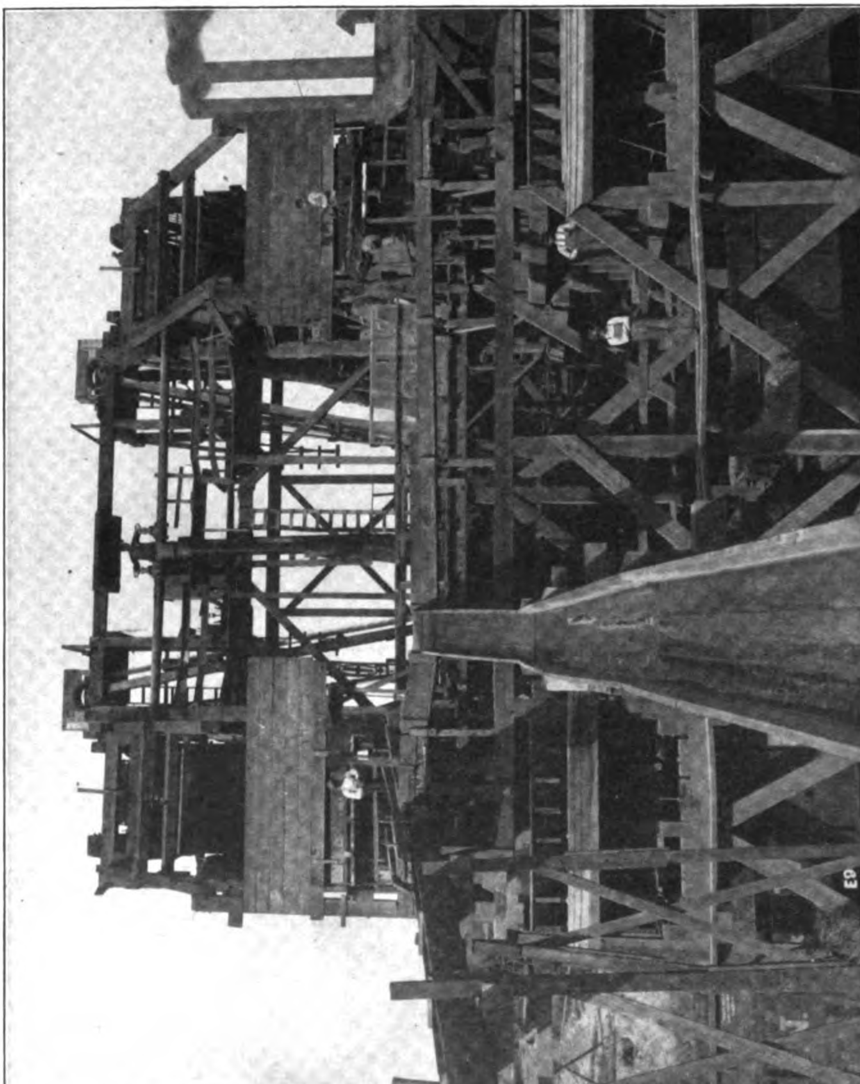


FIG. 7. DISCHARGED SEDIMENT OF GRAVEL WASHING, PLEASANT LAKE PLANT, LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

and to separate the sand from the gravel, loading the sand in cars on one track and the washed gravel in cars on another track. The stripping is done by grading machines and the material wasted. The gravel is loaded by means of a 75-ton steam shovel using a 3½-yd. dipper. The loading face is 40 ft. The material handles well. It is loaded into 40-yd. solid steel center dump ballast cars of 100,000 lbs. capacity. One hundred and twenty-five cars of this kind have been loaded as a maximum in one working shift of ten hours, in which the shovel was actually working seven and one-half hours. Two engines and crews are used to spot the cars at the shovel, haul the gravel to the washer and dump these in the hopper there. The cars are hauled up a stiff grade.

In Fig. 5 is shown the general layout of the plant. The pit is on the left. The engine shown is spotting each car at the hopper, from which the conveyors, shown in Fig. 6, are removing the pit-run gravel. This plant has two units, save its motive power and rock crusher. The discharge side of the washer is shown in Fig. 7. The prominent spout seen is the one which carries away the clay and loam with the water.

The Pleasant Lake plant is a wooden trestle structure on concrete foundations. It is driven by a 200-H.P. Erie steam engine. The water is supplied for this washer and engine by a Worthington 10-in. single-stage centrifugal turbine pump, rated at 2,400 gal., against a 90-ft. head. The pump has a 16-in. suction, 750 ft. long and 12-ft. lift. A test shows that 105 I.H.P. is required to drive the pump and 132 I.H.P. for operating the entire plant. About 1,700 gal. of water are used per day in actual operation. The conveyor for the pit-run or raw gravel is best seen in Fig. 6. It was furnished by the Link Belt Company and has a maximum capacity of 5,000 cu. yds. per day of ten hours. The gravel is elevated but once, and is discharged together with the water for washing on a flume 6 ft. wide and 8 ft. long. The water is allowed to escape from an 8-in. pipe through a "duck-bill" nozzle. This flume discharges on a bar screen with 2-in. spacing and a ¾-in. mesh wire screen below and parallel to it. The bar screen removes all stone and boulders, which at once pass to a Gates rock crusher, where the stones are all crushed small enough for ballast and returned to the bar screen again until all passes through into the ballast, thus improving the quality of the finished output. The materials having passed through the bar and ¾-in. screen pass successively over or through a 3-16-in. and ⅛-in. mesh, respectively. The gravel passing over these screens passes to the ballast cars and the sand to sand cars. The separation of the water from the sand in these large quantities gave some trouble at first. The sand settles, as shown in the skeleton side elevation, in a funnel with a valve at the bottom. The water and sand are admitted. The water flows over three sides of the square funnel and is wasted. When the funnel is nearly full of sand the attendant opens the valve and allows the sand to escape into the

bin below. Only stationary screens are used; revolving screens have proven unsatisfactory. The maximum capacity of this plant is 4,000 cu. yds. of raw or pit-run gravel per day of ten hours.

About 40 men are employed. This includes one steam shovel crew, four train crews and several men calking cars with lath, shingles and hay to make them hold wet sand.

The cost per cubic yard of the washed gravel varies much with the percentage of washed gravel obtained from the pit-run gravel. Some pits show 40 per cent., some 55 per cent. of washed gravel. Others show 65 per cent., while some pits promise to show 90 per cent. of washed gravel. The market for the sand has a considerable effect upon the net price of the finished product. Of course, the amount of stripping and the cost of the land are important elements. No general rule is safe, but it is not unreasonable to expect that pits may be found where the washed gravel would cost about twice as much as the raw or pit-run gravel.

CEMENTING GRAVEL.

There are two principal points in the territory east of Memphis where cementing gravel is worked for the purpose of supplying ballast to railroads; one at Iuka, Miss., on the Southern Railway, known as the Tishomingo Gravel Pit, owned and operated by the Tishomingo Gravel Company, of Memphis, Tenn., and one at Perryville, Tenn., on the Memphis & Paducah Division of the Nashville, Chattanooga & St. Louis Railway, owned and operated by the Perryville Gravel and Ballast Company, of Memphis, Tenn.

As the character of the gravel and the manner of working the two pits are somewhat different, they will be handled separately:

Tishomingo Gravel.—This is a water-worn gravel lying in a compact mass requiring blasting before it can be handled with a steam shovel. It is composed of 20 per cent. clay, 5 per cent. sand, and 75 per cent. gravel. This gravel as a rule is small and none of it large enough to require crushing to make it suitable for ballasting purposes. In order to get it in shape to load with steam shovel, it is loosened up by blasting. This is accomplished by digging a tunnel about 20x26 inches in cross-section into the material a distance of about 26 feet, then turning at right angles for a distance of 10 feet (see sketch, Fig. 8). This digging is done by a man lying down using a pick with a very short handle. The cost of digging these tunnels is 50 cents per foot.

The charge is placed in the extreme end of the tunnel and a portion of it refilled as shown on sketch. From 75 to 100 carloads of material is loosened up at each blast. This material is then loaded by steam shovel onto cars. The cost of this material is as follows:

Loading, per yard	$0.09
Hauling, per yard	0.20
Unloading and distributing	0.07
Putting under ties and surfacing	0.11
Total	$0.47

The advantages of its use are: Small cost, quick cementing qualities, holds track in line and surface well under fairly heavy traffic, does not churn, very little dust and has great resistance to erosion by water. Considered an excellent ballasting material. Has the disadvantage of growing prolific crops of weeds and grass, making it costly to keep clean.

Perryville Gravel.—This is an angular gravel lying in compact mass requiring blasting before it can be handled.

Large pockets of clay are encountered, making it preferable to load by hand in order to get the best material. It is composed of 10 per cent. clay and 90 per cent. gravel, with chemical analysis of 97 per cent. silica, 2.5 per cent. alumina, and .5 per cent. iron. There is found in this pit considerable large stone, which has to be crushed before suitable for use. The cost of this gravel per yard is as follows:

F. o. b. cars at pit, per yard	$0.27½
Hauling, 100-mile train service, per yard	0.20
Unloading and distributing	0.04
Stripping, putting under and surfacing	0.20
Total	$0.71½

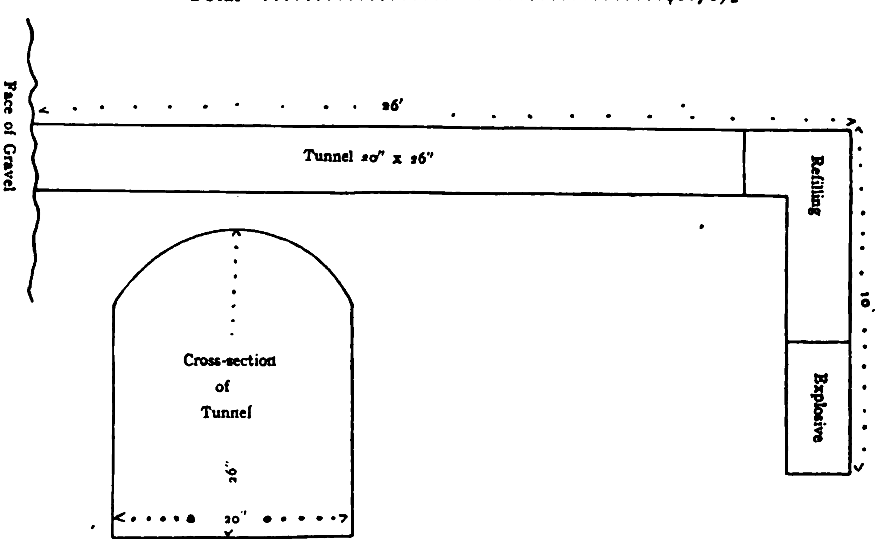


FIG. 8. SKETCH OF TUNNEL FOR BLASTING TISHOMINGO GRAVEL.

Advantages: Low first cost, ease of handling and getting under track, reduced cost for tie renewal, account of cementing qualities surface and line cheaply maintained under medium traffic, little dust, great resistance to erosion by water, making it valuable on track liable to overflow. This gravel gives some trouble churning and grows grass and weeds in profusion.

Your Committee is indebted to Mr. T. J. Howard, Roadmaster of the Southern Railway, Tuscumbia, Ala., for the information in regard to the Tishomingo gravel, and to Mr. W. B. Troy, President of the Perryville Gravel and Ballast Company, and Superintendent W. J. Hills, of the Memphis & Paducah Division of the Nashville, Chattanooga & St. Louis Railway, for information as to the Perryville gravel.

BURNT CLAY BALLAST.

The first step in preparing burnt clay ballast is the purchase of suitable land. The nature of the soil will determine its suitability for making ballast. Small test kilns should be burned, as the only satisfactory way of learning the behavior of the soil is a test under practically the same conditions as will exist in the pit.

Other determining factors in selecting a pit are convenience of arranging working and loading tracks and drainage of the pit. It is usually the case that suitable soil is found in some river or creek bottom and drainage is sometimes difficult to obtain. Lack of it, however, may cut a very considerable figure in the success of the pit. Where natural drainage cannot be had, it is usual to provide pumps to get rid of accumulations of water.

The method of operation is about as follows: For fuel to start with, a long pile of timber, usually old ties, is made along the ground parallel to one side of the location decided on for the pit. As tracks must be laid out for working, a convenient location for them may determine the direction of pile. The direction of prevailing winds should also be considered, as it will have considerable influence on the fires and consequently on the quality of the product. Coal is placed in the spaces between the timbers, the whole pile covered with soil to a depth of six to nine inches and the fires started. The soil is taken from a trench alongside of the pile of timbers and thrown over them by hand. On the opposite side of the trench from the timbers, usually at a distance of 48 ft., is laid the working track, this being laid on the natural ground without grading. The process then consists of putting onto the sloping side of the pile of timbers, coal and soil, called the kiln, alternate layers of coal and soil, the soil being dug from the bottom and sides of the trench and the working track being thrown over from time to time as necessary. The coal is handled direct to the fire from the cars. This may be done by hand, rigging platforms alongside the cars, so that the laborers may reach the right point conveniently, or by machinery designed for the purpose. The practice with respect to handling coal has sometimes been to unload into the trench directly from cars, mixing with the clay by the scrapers with which the latter was handled, but this method has not proven satisfactory. The method of mixing coal and clay in the trench has proven to be wasteful, besides giving a product which is unsatisfactory on account of lack of uniformity. The clay or soil may be excavated and thrown up by hand, but if a large quantity is to be burned the use of machinery

is economical. Machines have been used on the order of the grader, with an arrangement for carrying a plow on a car on the working track, this plow loosening soil, both on bottom and sides of trench, and throwing it onto a belt conveyor, which carries it to the desired point on the kiln.

These machines, however, have not proven satisfactory, and the type illustrated in Fig. 10 has been more successful. In working this machine, the scraper is dropped at the foot of the sloping side of the kiln and drawn toward the working track. When filled it is lifted, carried out over the fire and dumped. Each machine is fitted with two

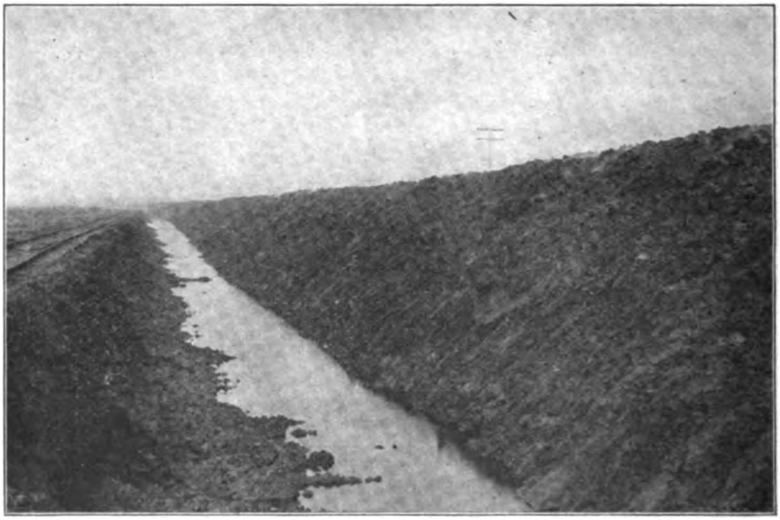


FIG. 9. BURNT CLAY BALLAST PIT.

scrapers, one of which is used to dump on the lower half of the slope of the kiln and the other on the upper half. Work of covering the side of the kiln is begun at one end and carried through to the other, after which a layer of coal is spread over the clay and the whole slope is gone over with large iron rakes, bringing some of the burning coal and hot clay into contact with the fresh coal, igniting the latter.

In addition to the coal handled direct onto the kiln, it is a usual or frequent practice to unload some on the ground alongside of the working track, also between ties of the latter. When the working track is shifted this coal is mixed with the clay excavated by the scraper.

The time at which coal and clay should be applied must be determined by the foreman in charge. The nature and condition of the soil, the size into which it is broken in handling, the quality and size of the coal used and the weather prevailing at the time are all factors

which enter into the problem of burning, and experience and intelligence are necessary to get good results. Obviously, fixed rules cannot be laid down.

To get the best product, the fires should be as hot as possible and the ballast should be allowed to cool down so as to permit safe handling. Under some conditions, five months' time will be sufficient for beginning loading after the fires are started, but the experience of some roads indicates that a year is better practice. Loading may be done by hand or steam shovel. If a large quantity is to be handled, the steam shovel is economical. With a large pit it is possible for the operations of

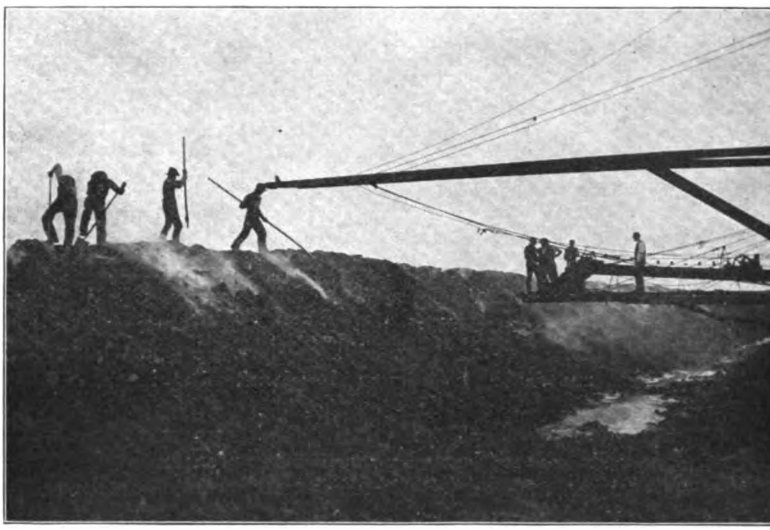


FIG. 10. MACHINE FOR LOADING BURNT CLAY BALLAST.

excavating, burning, cooling and loading to be carried on continuously, the loading being done on one side of the pit, while the excavating is being done on the other, the burning and cooling going on between the two.

In practice, however, the loading is carried on so much faster than the burning and cooling that the shovel soon gets into hot material. It is therefore better that the burning operations be completed before loading begins.

Contracts are seldom made for less than 100,000 cu. yds. per year. The plant should be capable of producing 500 to 1,000 yds. per day. A plant of this capacity requires one excavator, equipped with buckets and rakes, one slacking machine for distributing coal, one locomotive for switching loads and empties, one tool car, one blacksmith outfit and one pumping plant. The Railroad Company usually furnishes land,

fuel, track material and lays sidings for delivering fuel. The contractor furnishes plant and labor. Slack coal is generally used on account of cheapness and one ton burns 3½ to 4 yds. of ballast.

A good length of pit is a half mile, though pits have been burned as long as 4,000 ft. Some details of pit methods are given in an article in Engineering News, November 16, 1893, and the Committee is indebted to Mr. S. B. Fleming, President of the American Ballast Company, of Chicago, for information upon some of the practical points involved in making burnt clay ballast.

TABLE SHOWING COST OF BURNT CLAY BALLAST ON SEVERAL RAILROADS.

Railroad.	Land.	Fuel.	Contract Price.	Load-ing.	Train Service-Hauling.	Putting Under.	Total per Yard.
A. T. & S. Fe....	....	0.100	0.200	0.058	0.237	0.140	73.5
C. & E. I.......	....	....	....	....	....	....	25-30
C. B. & Q.......	0.45	0.135	0.17	0.06	....	....	41
C. M. & St. P....	....	....	....	....	....	....	38-40
C. R. I. & P.....	....	....	17-30	....	....	....	37-40
Union Pacific....	....	....	....	0.201	0.091	0.234	52.6
Wabash........	....	0.038	0.240	0.040	....	....	31.8

CHATS.

Chats are tailings from lead and zinc concentrators. The rock in which the lead and zinc occur is run through crushers and separators and thoroughly washed, after which it is discharged by means of elevators and troughs and forms the huge piles shown in Fig. 11. The desire of the lead and zinc operators to extract every ounce of ore from the rock has led to finer and finer crushing, so that chats coarse enough to make good ballast are becoming less easy to obtain each year.

A great deal of loading is done by hand under contract. The material is, however, most excellent for easy steam shovel handling, and much is loaded that way. Cost of loading is now about 16 cents per yard in the Joplin district, having been 14 cents for some years and at one time even cheaper.

ADVANTAGES AND DISADVANTAGES OF VARIOUS TYPES OF BALLAST.

Before going into the advantages and disadvantages of the different kinds of ballast, it seems worth while to state the functions of good ballast, with a view to noting more clearly to what extent the different ballasts perform them. These functions may be summed up as follows:

(1) To provide a medium for uniform distribution of the pressures and stresses in the rail from the ties to sub-grade.

(2) To insure a firm, smooth and level bearing for the ties.

(3) To quickly and thoroughly drain all water from the ties, reducing to a minimum conditions tending to decay.

(4) To provide a material between the ties to prevent the skewing and forward movement from the creeping tendency transmitted from the rail.

(5) To secure a material free from dust and dirt, thus preventing growth of grass and weeds.

(6) To provide a medium on which frequent adjustment of line and surface can be made, with as little disturbance to general conditions as possible, and which can be readily worked in renewal of ties.

(7) To insure freedom from the effects of the elements, such as frost-heaving, disintegration, etc.

(8) To provide a foundation which will give a certain degree of elasticity to the track, and insure even riding.

A good ballast should not become muddy when wet, and should be free from dust when dry. Either one of these conditions insures the other, and a dustless ballast is particularly desirable when there is a heavy passenger traffic, as the comfort of the passenger is seriously interfered with by clouds of dust filling the cars. Dust also has a certain wearing effect on all moving surfaces of the engine and cars, such as the journals, crosshead guides, etc.

The lines of transmission of pressure are important, in that they determine the area of sub-grade to which the load on the tie is transmitted. The discussion by Mr. W. C. Cushing, of the Pennsylvania Lines West, on the Committee's report contained in 1906 Proceedings. Vol. 7, p. 104, mentions some experiments made by Mr. Thos. H. Johnson, Consulting Engineer of the Pennsylvania Lines, to determine these lines of transmission. From Mr. Johnson's formulas it is evident that he has used one-fourth horizontal to one vertical for the line in gravel and one-half horizontal to one vertical for crushed rock. The Committee knows of no other experiments along this line. Mr. O. E. Selby, in his paper on "Stresses Existing in Track Superstructure" (Proceedings, Vol. 8, p. 52), has used these slopes, but does not mention any other experiments in confirmation.

CRUSHED ROCK.

A clear stone affords the best and quickest drainage, and, if kept free from dirt, does not grow weeds or grass, and, when well edged and trimmed, presents a far better appearance than any other kind of ballast. Where cementing qualities are low, and it is easily kept clean, it becomes a material which can be worked to better advantage during the winter months, as it does not freeze. This latter feature, furthermore, does away with frost-heaving and its consequent bad effects on line and surface. The statement is frequently made, especially by users of crushed rock ballast, that to quarry and deliver stone ballast on track increases its first cost over other materials, but its economic value

is much greater, owing to better track secured and longer life of ties, with less frequent necessity for relining and resurfacing.

Users of large quantities of gravel ballast, however, do not admit all of these claims, particularly that of better riding track. It is said that when track is to be raised only a very small amount, it is difficult to do this on stone ballast and to properly tamp the tie to an even and uniform bearing. For this reason it is claimed that gravel makes a more smooth riding track. Likewise, it is more difficult and costs more to renew ties in stone, owing to the handling of the material. We have also heard it stated by foremen that it is harder to make and maintain very small adjustments of line and surface in rock than in other materials, but its good qualities far outbalance its poorer ones, and its use shows a material economic saving. The spirit with which it is handled and the methods used are most important factors.

As stated before, the kind of ballast to be used is most frequently determined by local conditions, that is, whatever is most available, but when several kinds are to be had, it is very difficult to determine in exact figures under what conditions, weight of rolling stock and motive power and frequency of traffic it becomes most economical to begin the use of broken stone for ballast.

A passenger traffic might demand its use, more from the point of view of the comfort of passengers and its appearance than from actual pressures to be sustained. It would not be economical to ballast with stone a single track branch or feeder having a light freight business, where maintenance is not given the attention that is necessary on main lines. It is generally claimed that a saving will accrue from the use of stone of the proper qualities for ballast wherever it becomes necessary to support the heavy pressure and impact of the latest designs of engines, and this would be particularly true of roads carrying a large coal traffic in the latest design large capacity cars.

The best size for crushed rock is an unsettled question. Tests made on the Baltimore & Potomac Railroad, the results of which were obtained through the courtesy of Mr. Jos. T. Richards, Chief Engineer Maintenance of Way, Pennsylvania Railroad, indicate that there is a slight economy in the use of 2½-in. stone over 1½ in., and a decided saving over ¾-in. The tabulated result of these tests is given in the Proceedings, Vol. 5, p. 497.

In all probability, it will be found in future experience that the size of ballast will vary with the class of stone used. Smaller stone is desirable in securing smoother riding track, and for raising tracks an amount less than the size of the larger stones. In the harder rock, such as trap, smaller stone may be used, as it does not pulverize so readily from traffic and tamping. In limestone, the smaller sizes may be eliminated, as the larger sizes soon go to pieces, and, when the stone has high cementing values, this pulverizing constitutes one of its greatest disadvantages, and causes mud-pumping of the track.

Fine ballast is capable of producing smooth riding track with less labor, when it is first put in, yet does not hold track in as good line and surface under heavy traffic as ballast of larger size. Large size stone, with sharp fracture, holds the track in better line and surface under heavy traffic, but costs a little more for first tamping.

Very hard rock (such as trap or flint) is more satisfactory in smaller sizes than limestone. Limestone of high cementing power causes mud-pumping more quickly when crushed fine than when coarse, and an impervious cement mould is often found around the tie.

In tamping, it is found that the stone pulverizes badly, and that the smaller stone soon works into dust, requiring the ballast to be cleaned frequently. When this is done, only the larger stones are retained on the fork. It is found that the larger stones themselves, when tamped, break perhaps more than is actually necessary to furnish the required bearing for the tie, but this is partially due to the soft qualities of the stone.

Of interest in this connection is a statement of the Pennsylvania Railroad with regard to their practice: " . . . . . We are now using ballast of somewhat larger size than formerly, the specifications being for stone 'broken in cubical form not too large to pass through a three (3) in. test ring, nor small enough to pass through a one and one-quarter (1¼) in. test ring, and shall be graduated uniformly between these sizes. To be acceptable, trap rocks and other rocks in that class must withstand a crushing strength of not less than 10,000 lbs. per sq. in.; and all stones must pass such other tests as the Pennsylvania Railroad may think necessary to apply.' In regard to size, we find that the smaller stone formerly permitted in ballast is forked out with the dirt at every cleaning of ballast, entailing a large loss on the company. They also obstruct drainage more or less. We expect to get the best results from the size above specified. It is approximately the size used on our New York Division for a number of years."

Of further interest is a statement of results of physical tests of ballast stone, given in Appendix A to this report. This Appendix also contains descriptions of the various tests, geological descriptions of the rocks examined and a study of the costs and comparative economy of some of the stones, as they apply to conditions on the Baltimore & Ohio Railroad.

"Characteristics of Stone Ballast" on the Cleveland, Cincinnati, Chicago & St. Louis Railway are shown in Appendix B, which also contains some interesting comparisons of cost of stone and gravel ballast.

GRAVEL BALLAST.

The advantages of gravel ballast are lower first cost than crushed rock, lower cost of tie renewals and greater ease with which a light raise, to give a fine surface, may be made. The disadvantages are dust, inability to hold line and surface, churning when wet and allowing

growth of weeds. These disadvantages, however, exist in greatly varying degrees and in carefully prepared gravel ballast disappear altogether. While it is true that some of the users of crushed rock maintain that it is superior to the best gravel, your Committee feels that the evidence is not sufficient to warrant them in making an unqualified statement to that effect. Under extremely heavy traffic the indications are that crushed rock will stand better than the best gravel, but some of the best riding track in the country, with fast passenger service over it, and with reasonable maintenance expense, is put up on gravel.

Some physical tests of pit gravel on the Cleveland, Cincinnati, Chicago & St. Louis Railway have thrown light on the question of effect of sand and dust in gravel ballast, and the result of the tests is accordingly given here. These tests were made on small sieves by hand and must therefore be regarded as laboratory tests, rather than working tests under everyday conditions:

PERCENTAGE OF GRAVEL, SAND AND DUST BY VOLUME.

(Compared to Original Volume.)

Pit.	Division.	Gravel	Sand.	Dust.	Remarks.
Lafayette...........	Chicago........	81.6	27.0	1.3	Very Good.
Mechanicsburg........	Cincinnati........	61.3	50.9	2.8	Fair.
Mound City..........	Peoria..........	68.0	44.1	2.9	Good.
Savona..............	C. and Peoria....	86.0	12.5	6.5	Poor—Cementing nature.
Terre Haute (West)...	St. Louis........	56.0	62.0	2.0	Too recent to determine.
Valley Junction.......	Chicago.........	59.6	55.4	3.6	Good but dusty and excess of sand increases track labor.
West York...........	Cairo...........	58.7	49.1	12.9	Very poor. Only fit for sub-ballast.

In the discussion which follows the term "dust" is applied to that material which is finer than sand under the new definition recommended by the Committee. All proportions used in the discussion have reference to the bulk.

Gravel having 3 per cent. or less of dust has been found to drain very freely, while gravel having an excess of 3 per cent. of dust is found to hold water to such an extent as to interfere with its thorough efficiency as ballast.

Gravel containing 2 per cent. of dust will make a fairly dustless roadbed, but after being disturbed by track work it will cause considerable dirt until washed by a heavy rain.

It has been found necessary to have about 30 per cent. sand to partially fill the voids in the gravel. Lack of at least 20 per cent. of sand permits the pebbles to shift under the load and an excess of 50 per cent. of sand prevents the ballast from becoming firm. In dry weather action known as "pumping" or "blowing" takes place.

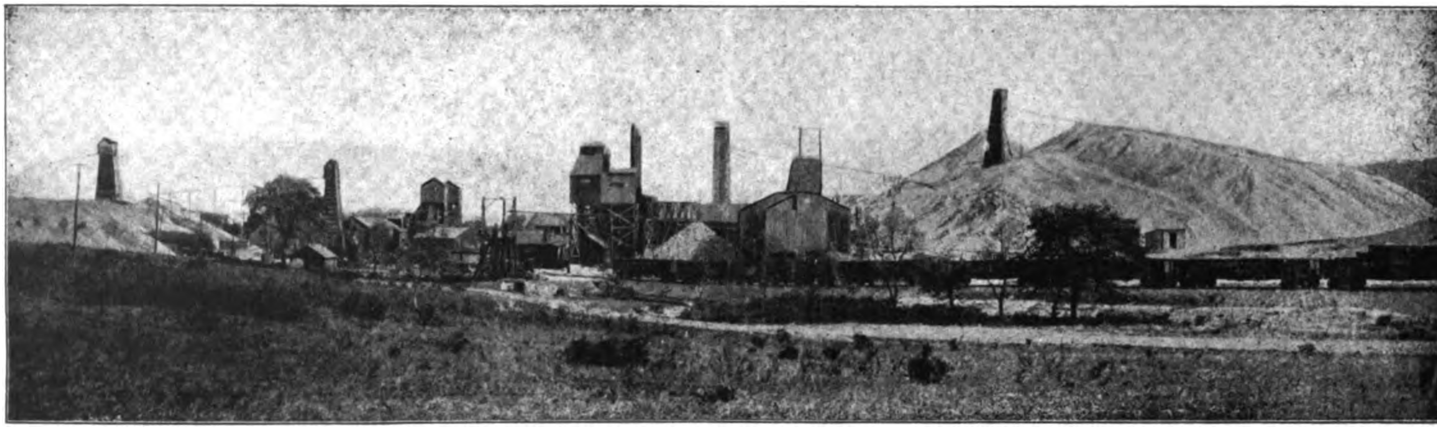


Fig. 11. Yellow Dog Zinc Mine, Webb City, Mo.

Your Committee recommends therefore, as a good practice, the following proportions:

For Class A roads: Ten parts Gravel and three parts Sand. Where bank gravel contains more than 2 per cent. dust or 40 per cent. sand it should be screened or washed.

For Class B roads: Ten parts Gravel and six parts Sand. Where bank gravel contains more than 3 per cent. dust or 60 per cent. sand it should be screened or washed.

For Class C roads: Ten parts Gravel and ten parts Sand. Any bank gravel which does not contain an excess of 6 per cent. dust may be economically used.

CHATS.

The principal advantage of chats is low first cost, although it has some very excellent qualities as ballast in addition to this.

It provides as good drainage as the best gravel, the coarser chats giving better drainage than the finer.

It is very low in cementing qualities and there are therefore fewer pumping ties than in gravel.

It is fine enough for ties to be tamped with a shovel or end tamper, permitting a fine surface with a light raise.

Weeds do not grow in the chats and they will not grow in the ballast until sufficient dirt to support them has been collected.

The specific gravity of chats varies from 2.54 to 2.66, and the weight of a yard varies from 2,100 to 2,400 lbs., averaging about 2,300 lbs. Recently the ore has been ground finer in order to get out more of the lead and zinc, which makes a less desirable ballast than when it is coarser.

Some of the disadvantages of chats are that they sink into clay soil, blow out under joints and do not keep tracks in good line and surface under heavy traffic. The better grades of chats, those made of the harder rocks and more coarsely crushed, have always been somewhat dusty under high speeds, say about 45 miles per hour. This objectionable feature has grown worse with the tendency to finer grinding, mentioned above, until it has reached the point where some chats piles are entirely unfit for ballast purposes. Some of the ore-bearing rock, also, is comparatively soft by nature, and, with clay which sometimes occurs in the interstices of the rock, makes a material which does not drain nor support track satisfactorily and which, therefore, should not be used except for sub-ballast.

Your Committee wishes to submit this as a progress report, rather than a complete one, both on preparation and delivery of ballast and a comparison of advantages and disadvantages. Some information has been obtained on the practice of treating ballast which has become foul under the ties, but this has not been put in shape to present.

CONCLUSION.

Your Committee asks that the definitions for Sand and Gravel be approved by the convention and that the percentages of sand and dust in gravel ballast given above be approved as good practice.

Respectfully submitted,

JOHN V. HANNA, Chief Engineer, Kansas City Terminal Railway, Kansas City, Mo., *Chairman.*

C. A. PAQUETTE, Assistant Chief Engineer, Cleveland, Cincinnati, Chicago & St. Louis Railway, Cincinnati, O., *Vice-Chairman.*

WILLARD BEAHAN, Assistant Engineer, Lake Shore & Michigan Southern Railway, Cleveland, O.

W. J. BERGEN, Assistant to Chief Engineer, New York, Chicago & St. Louis Railway, Cleveland, O.

J. B. DICKSON, Assistant to General Manager, Erie Railroad, New York.

H. O. GARMAN, Assistant Professor of Civil Engineering, Purdue University, Lafayette, Ind.

H. E. HALE, Assistant Engineer, Missouri Pacific Railway, St. Louis, Mo.

G. D. HICKS, Superintendent, Nashville, Chattanooga & St. Louis Railway, Tullahoma, Tenn.

B. C. MILNER, Louisville, Ky.

A. F. RUST, Resident Engineer, Kansas City Southern Railway, Kansas City, Mo.

W. C. SMITH, Engineer Maintenance of Way, Northern Pacific Railway, St. Paul, Minn.

F. J. STIMSON, Engineer Maintenance of Way, Grand Rapids & Indiana Railroad, Grand Rapids, Mich.

A. W. THOMPSON, Chief Engineer Maintenance of Way, Baltimore & Ohio Railroad, Baltimore, Md.

G. M. WALKER, JR., Roadmaster, Santa Fe Railway, Vaughn, N. M.

Committee.

Appendix A.

PHYSICAL TESTS OF CRUSHED STONE BALLAST USED ON THE BALTIMORE & OHIO RAILROAD.

Tests of all these rocks have been made by the United States Government, Department of Agriculture, Office of Public Roads, with the following results:

TESTS OF GNEISS FROM WOODDALE QUARRY, B. & O. R. R.

Specific gravity	2.80
Weight per cubic foot ... lbs.	175.00
Absorption of water	.37
Per cent. of wear	3.90
French coefficient of wear	10.30
Hardness	17.70
Toughness	6.00
Cementing value	High

REMARKS.—Poor ballast. The B. & O. R. R. is now using this stone. In April, 1908, received 43 per cent. screenings.

TEST OF TRAP ROCK (GABBRO).

Specific gravity	3.15
Weight per cubic foot ... lbs.	196.00
Absorption of water	.27
Per cent. of wear	1.90
French coefficient of wear	21.50
Hardness	17.30
Toughness	15.00
Cementing value	10.00

TEST OF TRAP ROCK (DIABASE) FROM QUARRY OF REEL'S MILLS, MD.

Specific gravity	3.0
Weight per cubic foot ... lbs.	187.00
Water absorption	.4
Per cent. of wear	1.1
French coefficient of wear	36.4
Hardness	18.8
Toughness	21.0
Cementing value	17.0

TEST OF TRAP ROCK (GABRO) FROM MANNING QUARRY, LAUREL, MD., USED IN GOVERNMENT WORK.

Specific gravity	2.9
Weight per cubic foot ... lbs.	180.90
Absorption of water	0.1
Per cent. of wear	2.1
French coefficient of wear	18.7
Hardness	17.3
Toughness	24.0
Cementing value	3.6

TEST OF TRAP ROCK (DIABASE) FROM GOVERNMENT QUARRY AT DICKERSON, MD.

Specific gravity	3.00
Weight per cubic foot, lbs.	187.00
Water absorption	.39
Per cent. of wear	2.00
French coefficient of wear	20.20
Hardness	18.50
Toughness	25.00
Cementing value	27.00

TEST OF SHENANDOAH LIMESTONE FROM ENGLE'S QUARRY, NEAR MARTINSBURG, W. VA.

Specific gravity	2.7
Weight per cubic foot, lbs.	168.00
Water absorption	.3
Per cent. of wear	4.5
French coefficient of wear	9.0
Hardness	11.8
Toughness	4.0
Cementing value	41.0

TEST OF HELDERBERG LIMESTONE FROM KEARNEYSVILLE QUARRY, NEAR MARTINSBURG, W. VA., ON B. & O. R. R.

Specific gravity	2.75
Weight per cubic foot, lbs.	172.00
Water absorption	.63
Per cent. of wear	4.20
French coefficient of wear	9.60
Hardness	14.70
Toughness	5.00
Cementing value	68.00

TEST OF SHENANDOAH LIMESTONE FROM QUARRY ON FROG HOLLOW BRANCH, B. & O. R. R., NEAR MARTINSBURG, W. VA.

Specific gravity	2.70
Weight per cubic foot, lbs.	168.00
Water absorption	.26
Per cent. of wear	8.30
Hardness	16.70
Toughness	4.00
Cementing value	52.00

TEST OF HELDERBERG LIMESTONE FROM QUARRY AT KEYSER, W. VA., ON THE B. & O. R. R.

Specific gravity	2.70
Weight per cubic foot, lbs.	168.00
Water absorption	.35
Per cent. of wear	4.00
French coefficient of wear	10.00
Hardness	16.20
Toughness	7.00
Cementing value	43.00

TEST OF GREENBRIER LIMESTONE FROM BUCKHORN QUARRY, NEAR ROWLESBURG, W. VA.

Specific gravity	2.65
Weight per cubic foot, lbs.	165.00
Water absorption	.34

Per cent. of wear	2.20
French coefficient of wear	18.20
Hardness	18.00
Toughness	14.00
Cementing value	35.00

TEST OF CORNIFEROUS LIMESTONE FROM QUARRY OF SCIOTO STONE CO., NEAR COLUMBUS, OHIO, ON B. & O. R. R.

Specific gravity	2.60
Weight per cubic foot	lbs. 152.00
Absorption of water	1.34
Per cent. of wear	3.10
French coefficient of wear	12.90
Hardness	12.00
Toughness	12.00
Cementing value	Good

TEST OF LOWER HELDERBERG LIMESTONE FROM QUARRY AT NORTH BALTIMORE, OHIO, B. & O. R. R.

Specific gravity	2.75
Weight per cubic foot	lbs. 172.00
Absorption of water	.37
Per cent. of wear	4.30
French coefficient of wear	9.30
Hardness	12.80
Toughness	9.00
Cementing value	32.00

ABRASION TEST.

In making these tests the Government used the following methods:

The machine consists of four cast-iron cylinders closed at one end and furnished with a tightly fitted iron cover for the other end. The cylinders are 20 cm. in diameter and shaft at an angle of 30 degrees with the axis of rotation.

The rock is broken into pieces as nearly uniform in size as possible, and as nearly 50 pieces as possible constitute a test sample. The total weight of rock in a test is within 10 grams of 5 kilograms. All test pieces are washed and thoroughly dried before weighing. Ten thousand revolutions, at the rate of between 30 and 33 to the minute, constitute a test. Only the percentage of the material worn off which will pass through a 0.16 cm. ($\frac{1}{16}$-in.) mesh sieve is considered in determining the amount of wear. The amount of wear is expressed either in the per cent. of 5 kilograms used in the test, or the French coefficient, which is in more general use, is given; that is,

$$\text{The coefficient of wear} = 20 \times \frac{20}{w} \text{ equals } \frac{400}{w},$$

"w" being the weight in grams of the detritus under 0.16 cm. ($\frac{1}{16}$-in.) in size per kilogram of rock used.

TEST FOR HARDNESS.

A cylindrical core 25 mm. in diameter is cut from a specimen of the rock with a diamond core drill, and the test piece is held perpendicularly against a revolving cast-iron disc under a constant pressure of 1,250 grams, while standard sand is fed on the disc to act as the abrasive agent. At the end of 1,000 revolutions the loss in weight is determined and the test repeated with the specimen reversed. The average loss in weight, computed from the two runs, is used in determining the hardness of the rock. In the earlier work, the loss in length was determined from measurements taken before and after each run, and the average loss expressed in mm. per 1,000 revolutions subtracted from 20, was given as representing the hardness of the specimen. The arbitrary constant 20 was selected with a view to giving the results of this test about the same range of variation as the French coefficient of wear which has been previously discussed. It has been found, however, that the hardest rocks lose only about 2 mm. per 1,000 revolutions, while some of the softer varieties lose considerably more than 20 mm., thus giving rise to negative values in the results of the test. In order to avoid this, a different method of expressing the hardness has been adopted, viz.:

$$\text{Hardness equals } H - 20 - \tfrac{1}{3} w \text{ ——————— } (2.)$$

where H equals loss in grams per 1,000 revolutions.

RESISTANCE TO IMPACT.

This test is made on 25 mm. x 25 mm. (0.98-in.) rock cylinders with an impact machine especially designed for the purpose. Instead of a flat-end plunger resting on the test piece as in the cementation test, a plunger with the lower bearing surface of spherical shape, having a radius of 1 cm. (0.4-in.) is used. It can be seen that the blow as delivered through a spherical-end plunger approximates as nearly as practicable the blows of traffic. Besides this, it has the further advantage of not requiring great exactness in getting the two bearing surfaces of the test piece parallel, as the entire load is applied at one point on the upper surface. The test piece is adjusted so that the center of the upper surface is tangent to the spherical end of the plunger, and the plunger is pressed firmly upon the test piece by two spiral springs, which surround the plunger guide rods. The test piece is held to the base of the machine by a device which prevents its rebounding when a blow is struck with the hammer. The hammer weighs 2 kg., and is raised by a sprocket chain and released automatically by a concentric electro-magnet. The test consists of a 1 cm. fall of the hammer for the first blow, and an increased fall of 1 cm. for each succeeding blow until failure of the test piece occurs. The number of blows required to cause failure is used to represent the toughness.

CEMENTATION TESTS.

One-half kg. of the rock to be tested is broken sufficiently small to pass through a ¼-in. mesh. This material is placed in a ball mili, together with about 85 cc. of water sufficient to produce a stiff paste after grinding. This mill contains two steel shot, weight of 25 lbs. each, and is revolved at the rate of 2,000 revolutions per hour. At the end of 5,000 revolutions, the material is taken from the mill, and about 28 grams of the dough is placed in a cylindrical metal die, 25 mm. in diameter. A closely fitting plug supported by guide rods is inserted over the material, which is then subjected to a pressure of 100 kgs. per sq. cm. The die is placed on an iron platform supported by a piston rod, which is connected directly with a hydraulic piston below. Water from a tank is admitted to the hydraulic cylinder through a small orifice in the pipe. As the piston rises, the platform and die are carried up with it, the plug of the latter coming in contact with the yoke attached to a properly weighted lever arm. The height of the briquette is measured and if it is not exactly 25 mm., the requisite amount of material is added or subtracted to make the next briquette the required height. Five briquettes are made from each test sample and allowed to dry 20 hours in air and 4 hours in a steam bath. After cooling for 20 minutes in a desiccator, they are tested by impact in a machine especially designed for the purpose.

This machine consists of a one kg. hammer which falls on a flat-end plunger of 1 kg. weight, which is pressed upon the briquette by two light spiral springs surrounding the guide rods. By a suitable recording device, the movement of the plunger during and after each blow of the hammer is recorded. The standard fall of the hammer is 1 cm. and this blow is repeated until the bond of cementation of the material is destroyed. The number of blows required to destroy the bond of cementation as described above is noted, and an average obtained from five briquettes is given as the cementing value.

GEOLOGICAL DESCRIPTION OF TRAPS.

The trap rocks (Gabbro and Diabase), which make the best ballast and which are now used to a great extent on the Pennsylvania Railroad, are described geologically as follows:

DESCRIPTION OF TRAPS.

The trap rocks are highly crystalline, with the minerals that compose them firmly interlocked. Some are rich in iron, that being the basis of what little cementing power they have.

They are of igneous origin, having been forced in a molten condition from considerable depths in the earth's crust into the position they now occupy. They occur in several well-defined varieties.

Gabbro (Niggerhead).—The oldest of the basic eruptive or trap rocks which intrude the gneiss. There are three main areas:

The stony forest of Hartford and Cecil Counties, Maryland.

The sheet that extends from north of Conowingo on the Susquehanna, in a southwest direction, to Baltimore City.

The irregular intrusive sheet which is mainly developed to the west of Baltimore, and extends as far south and west as Laurel.

The Gabbro is a rather fine-grained aggregate of the minerals:

Hypersthene (1),
Diallage (2),
Plagioclase (3),
and Magnetite (4),
with varying amounts of Apatite (5),
and Brown Hornblende (6).

The unaltered Gabbro is usually heavy and dark colored.

(1) Gray or greenish black, often with a peculiar, bronze-like color on the cleavage surface. (Looks rusty.)

(2) Dark green or bronze colored variety of pyroxene. Pyroxene is a common mineral, occurring in minerals having one oblique inclination (monoclinic). It is an essential constituent of gabbro and basalt.

(3) A general term for any triclinic feldspar. Feldspar is a general name for a group of minerals closely related in crystalline form, and all silicates of alumina with either potash, salt or lime. It breaks in two directions at right angles.

(4) An oxide of iron ($Fe_3 O_4$). Iron ore sometimes called magnetic iron.

(5) Native phosphate of lime. Occurs in six-sided prisms. Pale green.

(6) The common black or dark green or brown variety of amphibole. It belongs to the aluminous division of the species, and contains considerable iron. Amphibole is Silicate of Magnesium and Calcium, with usually aluminum and iron.

The Gabbro does not easily decompose, and so is found often in the form of round boulders. The road cuts of Edmonson Avenue, in Baltimore, show them in this form in many places. It is so hard and so heavy that it cannot be quarried for a building stone, but it is much used for road material in Baltimore County. It is highly esteemed, on account of its excellent wearing qualities.

Diorite.—Diorite is closely allied to granite and might easily be mistaken for it. It differs in the character of its Feldspar, and in its darker color. Quartz is usually present and also a green hornblende. Under a microscope the diorites often show signs of weathering. The diorites have less iron than Gabbro, and do not cement as much. It is found along the Patapsco River, just north of Ilchester Tunnel, on the west side of the river.

Diabase.—The youngest of the trap rocks and the hardest, toughest and most expensive to work. It occurs in two long dikes reaching across the state of Maryland from northeast to southwest. In the western dike, which crosses the main line of the B. & O. R. R. about

two miles east of Frederick Junction, and the Metropolitan Branch, near Dickerson, the diabase penetrates the sandstones and shales.

In the eastern portion of the Piedmont Plateau it intrudes the older crystalline rocks in Baltimore and Howard Counties. The dike crosses the main line about one mile west of Alberton, and disappears near Samsonville, about four miles north of Laurel. It crosses the Northern Central Railroad near Parkton.

Diabase is composed of feldspar, pyroxene, with olivene and magnetite.

(Olivene is a yellowish green mineral, composed of silica, magnesia and iron.)

SAVING EFFECTED BY USE OF TRAP FOR BALLAST.

From tests of these trap rocks, it is readily seen that a material saving can be effected by their use for ballast purposes. Less stone will be required to maintain the track, and it can be used in smaller sizes, as its higher percentage of hardness and toughness will insure less breaking under traffic and tamping.

Figures taken from comparison of line and surface in trap with that in stone whose quality is about the same as limestone, show that line and surface cost approximately $20 less per mile in trap than in limestone.

COST OF PLANT.

From published figures, the cost of building a plant of 1,000 tons daily capacity, and its cost of operation to quarry, is as follows:

ESTIMATE COST OF QUARRY PLANT.

GABBRO.

Capacity 1,000 tons daily	300,000 tons annually
900 cu. yds. trap per 10-hour day	270,000 cu. yds. "
Crushers, 4, 250-ton Farrell, at $1,250	$ 5,000
Engines, 4, 60-H.P., 14x12, at $500	2,000
Foundations	100
Belting, 13-in., 200 ft., at $2.75	550
Boilers, 2, 200-H.P. and setting	7,500
Steam fittings	4,000
Boiler House	2,500
Engine House	1,500
Stack	2,000
Scales, 60-ft., including foundations and timber	1,225
Bins	600
Elevators with platforms, 4 at $1,500 (for tailings)	6,000
Pump for water supply, 5,500 gallons per hour	200
Tank, 50,000 gallons	1,200
Steam drills with tripods connecting hose, 20 at $245	4,900

Screens, rotary, 54-in., 4 at $950	3,800
Small Tools, Forges, Bars, Wedges, Hammers, etc.	1,200
Derrick, small stiff leg	150
Total	$44,425
Contingencies, 8 per cent	3,553
	$47,978
Land, 50 acres at $150 per acre	7,500
Cable railway and dump cars for haul to crusher, this being a varying item as quarry is worked	5,000
Total cost of quarry	$60,478

COST OF OPERATION OF QUARRY PLANT.

GABBRO.

Capacity 270,000 Cu. Yds. Per Annum.

18 drillers at $3 per day, 300 days		$16,200
18 helpers at $1.75 per day, 300 days		9,450
3 blacksmiths at $3 per day, 300 days		2,700
50 bar-sledgers at $1.75 per day, 300 days		26,250
60 coal loaders at $1.75 per day, 300 days		31,500
8 crusher men at $1.75 per day, 300 days		4,200
1 quarry boss at $5 per day, 300 days		1,500
1 fireman at $2.50 per day, 300 days		750
1 engineer at $3 per day, 300 days		900
4 bin men at $1.75 per day, 300 days		2,100
1 scale man at $2 per day, 300 days		600
1 carpenter at $3 per day, 300 days		900
10 laborers at $1.75 per day, 300 days		5,250
1 clerk at $750 per year		750
Fuel, 2,700 tons of coal at $2.70		7,290
Oil, waste, etc.		500
Dynamite, .7-lb. per cu. yd., 270,000 cu. yds.—189,000 lbs. at 15 cents		28,350
Drill repairs—1 machinist at $4		1,200
1 helper at $2.50		750
Supplies at $1.25 per mo. per drill		270
Blacksmiths included above		......
Total		$141,410
4 per cent. on first cost of plant	$2,418	
10 per cent. depreciation on machinery, except crushers	2,160	
16⅔ per cent. depreciation on crushers	833	
		5,411
		$146,821
Contingencies, 8 per cent		11,750
		$158,571

This shows a cost per yard of 59 cents.

SAVING FROM USE OF TRAP VS. LIMESTONE ON TYPICAL SECTION.

With this figure, the estimated saving shown from the use of trap rock (Gabbro) over limestone now used, from Martinsburg quarry, on the Baltimore & Ohio Railroad, in a 16-mile section, double-track, or 32 miles of single track, based on changing the entire ballast in a five-year period, and using 2,200 cu. yds. of trap rock per mile, 8-in. under the tie, would be as follows:

DETAILS OF COST PER CUBIC YARD IN TRACK.

Gabbro.

Quarrying	$0.60
Placing in track	.15
Average haul, 18 miles at .001	.02
Total estimated cost per cu. yd.	$0.77

Limestone.

Quarrying	$0.55
Screenings, 33 per cent	.18
Placing in track	.15
Average haul, 98 miles at .001	.10
Total actual cost per cu. yd	$0.98

SUMMARY.

Limestone, 14,080 cu. yds. at 98 cents	$13,798.40
Gabbro, 14,080 cu. yds. at 77 cents	10,841.60
Saving per year during ballasting, due to use of Trap Rock	$ 2,956.80

SAVING IN MAINTENANCE.

300 cu. yds. of trap rock per mile per year will maintain track as efficiently as 400 cu. yds. of limestone.

32 miles × 400 cu. yds. Limestone × 98 cents	$12,544
32 miles × 300 cu. yds. Trap Rock × 77 cents	7,392
Saving per year due to use of Trap Rock after track is fully ballasted	$ 5,152
Saving in line and surface, 32 miles at $20	640
Total saving per year after track is fully ballasted	$ 5,792

SAVING IN MAINTENANCE LABOR.

Saving in maintenance labor during ballasting:	
1st year	...
2nd year, 6.4 miles × $20	$128
3rd year, 12.8 miles × 20	256
4th year, 19.2 miles × 20	384
5th year, 25.6 miles × 20	512
Total five years labor saving during ballasting (Maintenance)	$ 1,280.00
Five years saving in first cost, due to use of Trap Rock	14,784.00
Total five years saving during ballasting	$16,064.00
Average saving per year during ballasting	3,212.80
Saving per year after fifth year	5,792.00

NECESSITY FOR STUDY OF ECONOMIC VALUES OF BALLAST.

These figures give an idea of the savings which may be effected by going into such questions thoroughly, and getting accurate data.

Such comparisons may be worked up for stone, gravel and cinder, and estimate made which will show a railroad management how far they are justified in going into such economies.

BENEFITS FROM USE OF TRAP.

The physical benefits which may be expected to come from the use of Trap Rock can be summed up as follows, and it would appear that wherever stone is available within the limits of reasonable haul, that its use is unquestionably economical:

(1) By holding up ties under the rail seats more firmly and longer, danger of center-bound track is decreased and many broken ties saved.

(2) By virtue of the hardness and low cementing power of Trap Rock, the water will be drained away from the ties quickly, and thus lessen the tendency to decay. This may have an important bearing on the prolonging of the life of the tie.

(3) The expense of maintaining line and surface is necessarily less in a ballast that stands up and does not pulverize, allowing the track to sink and shift laterally.

(4) By standing up under track, the tendency to broken rails, broken joints and spike-pulling is lessened.

(5) With better drainage, disturbances from frost-heaving are minimized.

(6) Smaller sized ballast may be used with a hard ballast than with soft stone. A more even bearing may be secured by its use.

(7) The sharp fracture of the Trap Rock is instrumental in securing a wide distribution of the loads transmitted by it to the sub-grade.

POSSIBLE CHANGES IN ROADBED SECTIONS DUE TO USE OF TRAP.

Cross-sections adopted by the important railroads of the country, to cover broken stone ballast, have been published by the American Railway Engineering and Maintenance of Way Association, but it is possible that, in the future, it may be found that the cross-sections can be changed, when so satisfactory a material as Trap is available for ballast purposes.

POSSIBLE CHANGES IN TIES.

Again, the length of tie may be changed in the future, and shortened, in accordance with conditions found from experiments made by M. Cuenot, Chief Engineer of Bridges and Highways, Paris-Lyons-Mediterranean Railroad Company, translated by Mr. W. C. Cushing, Chief Engineer Maintenance of Way, Pennsylvania Lines West of Pittsburg, under the title of "Deformations of Railroad Tracks and the Means of Remedying Them."

Appendix B.

CHARACTERISTICS OF STONE BALLAST USED ON BIG FOUR RAILWAY.

(1) SPECIFICATIONS FOR ROCK BALLAST.

Stone ballast is to be made of trap, limestone or other hard durable rock. It must be free from earth, shale or other foreign substance.

The rock is to be crushed so that it will pass through a 2-in. ring. The largest ring in screen used in screening rock ballast must be 2-in. in diameter. If stone larger than 2-in. is taken from any screen there must be efficient partition and bins to absolutely separate the stone passing through the 2-in. ring.

All stone finer than stone passing through a 2-in. ring will be taken excepting such stone as will pass through a ½-in. ring.

(2) ORIGIN AND COST OF STONE AND AMOUNT NOW IN TRACK.

In general the stone ballast on the Big Four has been obtained from two sources. First, from Marion, Ohio, where it is purchased from the Ohio and Western Lime Company. This stone is a fair, hard limestone, and has proven durable. The cost at present is 54 cents per cu. yd. delivered on cars. The quarry is located on a foreign line, causing a switching charge of $2 per car. This makes an extra charge of 5 cents per cu. yd., making the cost of the stone 59 cents per cu. yd. on Big Four tracks. This ballast is hauled 101 miles maximum haul and the present minimum haul is 32 miles, making an average haul of 66 miles. The Big Four Railway from Cleveland to Shelby, Ohio, is ballasted with this stone, making a total of 102 miles of track. This stone has been applied to average of 2,100 cu. yds. per mile. The average amount of stone under the track is 8 in. on firm bed of gravel and slag.

The other source of stone ballast on the Big Four is Southern Illinois. This stone is a hard, durable sandstone and is the only ballast material available in the territory in which it is used. The crushing plant is owned by the company, and the average cost of production for one year (1907) was 48 cents per cu. yd. on cars. The character of the stone does not make it desirable for ballast, but for the conditions under which it is used good results were obtained. The track ballasted with this stone extends from Cairo, Ill., to Harrisburg, Ill., and the quarry is located near Vienna, Ill., 36 miles north of Cairo.

(3) COST OF APPLYING STONE BALLAST.

(a) Cleveland Division (Hard Limestone, 1908), 31.9 cents cu. yd.
(b) Cairo Division (Hard Sandstone, 1907), 31.0 cents cu. yd.

(4) COST OF TIE RENEWALS IN STONE BALLAST.

Cleveland Division (1908), 16.8 cents.

(5) RENEWALS OF BALLAST.

The greater portion of our stone ballast has been in less than five years. It has not been necessary to make a renewal of ballast because of it being worn out.

COMPARISON BETWEEN STONE AND GRAVEL BALLAST.

(1) COST OF BALLAST.

As stated, the stone ballast on cars on our track costs 59 cents and 48 cents per cu. yd. Gravel ballast on cars, including all costs, ranges from 5.62 cents to 13.9 cents per cu. yd.

(2) COST OF APPLYING.

Stone ballast cost to put under track in 1908 31.9 cents per cu. yd. Gravel ballast cost 11.8 cents per cu. yd., the amounts of lift and train service being practically equal.

(3) COST OF TIE RENEWALS.

Tie renewals in stone ballast averaged 16.8 cents per tie and in gravel ballast 10.3 cents.

(4) EFFICIENCY OF THE BALLAST.

On the Big Four ballast cross-section for stone is used which with a 12-in. lift requires an average of 3,380 cu. yds. per mile under the same conditions a gravel cross-section having 3,680 cu. yds. per mile is used. Results have indicated that the stone cross-section might be even further reduced and obtain results so far as maintaining surface is concerned equal to that of gravel. It may be said, therefore, that for the same conditions the volume of stone required may be 10 per cent. less than gravel.

DISCUSSION.

Mr. John V. Hanna (Kansas City Terminal):—The work done by the Committee this year was principally the compiling of information and we have not, therefore, very much to submit to the Association in the form of conclusions. In fact, the only thing we have in that line is a change in some definitions, and some recommendations as to proportions of sand and gravel for different classes of service. We did not want to go into the question of definitions, as we did some years ago, but when it came to distinguishing between gravel and sand as ballast material, it seemed necessary to draw a line arbitrarily. One of the members of our Committee, the vice-chairman, made some actual separations with screens of different sizes, the result of which was that we offer a definite line to be drawn between those two classes of material. The rest of the work was along the line of describing methods of preparing and delivering ballast of the different kinds, and also something on the advantages and disadvantages of the different classes of ballast. In the appendix to the report is some other matter that we thought would be of interest and value to the Association, and we submitted it accordingly. I should have preferred that the explanation of the work actually done in arriving at these screen sizes in separating sand and gravel had been made by Mr. Paquette, the vice-chairman of the Committee, who actually carried out these tests. As I am not able to do so, and Mr. Paquette is not here, we cannot give it. I would move that the conclusions of the Committee in that respect be adopted.

The President:—The Secretary will read the conclusions.

The Secretary:—"That the percentages of sand and dust in gravel ballast given below be approved as good practice:

"For Class A roads: Ten parts gravel and three parts sand. Where bank gravel contains more than 2 per cent. dust or 40 per cent. sand it should be screened or washed.

"For Class B roads: Ten parts gravel and six parts sand. Where bank gravel contains more than 3 per cent. dust or 60 per cent. sand it should be screened or washed.

"For Class C roads: Ten parts gravel and ten parts sand. Any bank gravel which does not contain an excess of 6 per cent. dust may be economically used."

Mr. L. C. Fritch (Illinois Central):—It seems to me the percentage of sand in the gravel for Class A roads is a little high. I would like to hear some discussion on that point. It strikes me that 30 per cent. would be better.

Mr. C. E. Lindsay (New York Central):—The Committee recommends the substitution of a definition for gravel for the definition for gravel which is given in the Manual. I would request that we have the definition for gravel as given in the Manual read to us.

The Secretary:—"Gravel.—Small worn fragments of rock, coarser than sand, occurring in natural deposits."

Mr. Lindsay:—I hope the conclusions of the Committee changing the Manual will not be adopted. It seems to me that the proper definition for gravel is as it occurs naturally. Just last month I was attending upon a lawsuit where the question of the character of the ballast was in dispute and around which the question centered, and it was a question whether it was a gravelly sand or a sandy gravel. We claimed that it was the best that could be obtained in that locality in its natural condition. If this Association goes on record as saying that a gravel ballast is a mixture of a certain definite quantity of sand and gravel, it seems to me we are going along the wrong lines.

Mr. Hanna:—I would say the idea of the Committee was to draw a definite line between what was sand, what was gravel and what was dust. It is true that gravel is a natural deposit; so is sand a natural deposit. Ordinarily there is no confusion in anybody's mind as to what these things are; but when it came to a discussion of them for ballast purposes, it seemed to the Committee that there was an advantage in having some definite test that the material could be put to, which would determine which class it would go into. That matter would have been clearer, I think, if we had here the samples of the material itself, which would show just exactly what is obtained by making the separation by means of the screens we have named in these definitions. I think, in the absence of the actual material before you to see what it means to draw this line, that it is very difficult to convey the right impression about it. We had intended to have the samples here so they could be seen. In the report we give the proportion of parts of gravel and sand. I am not able myself to say just what led to these particular proportions. They were determined by Mr. Paquette, who is chairman of the sub-committee, and they are the results of his work in using these different sizes of screens. The idea was that the proportion of sand should be as large as possible, keeping in mind the desirability of filling the voids between the stones of the gravel, and that the sand should not be in large enough proportion to permit dust, or permit the sand to be drawn up by the air going along with a moving train. At high speed the trains would naturally pick up particles of a larger size than slower trains, and the idea was that for first-class roads there would not be enough sand to be at the surface of the gravel—naturally the finer stuff worked down through.

Mr. Maurice Coburn (Vandalia Line):—I have not had any actual experience with washed gravel, but I have recently been interested in the subject and made some recommendations for our road. Our gravel at the present time does not have sand enough in it to fill the voids in its natural condition. I am recommending that a good deal of the sand be removed. I think, as Mr. Fritch suggests, that the percentage of sand recommended is too high. The larger the amount of sand the more dust we are going to have, the less the life of the gravel is going to be and the poorer the drainage we are going to have. The reason for washing the gravel is to secure all those results. With us, with our present gravel,

the dust is a very serious matter in the summertime. I am very glad to read what the Committee has had to say about the comparison between the gravel in the stone, because it agrees with my own conclusions. Our road has enough traffic so that we have built some double track and we want some more pretty badly, and I think with our traffic and with the prospective traffic for a good many years, that the gravel ballast will give us first-class track for considerably less than we will have to pay using stone, and we have both stone and gravel on our division. Of course there may be some cases where good gravel deposits, suitable for washing, are not available and that may alter the conditions very much.

Mr. L. C. Fritch:—Going back to the subject of the percentage of sand, I will say that our road has had considerable experience in river gravel, where we could get any desired quantity of sand, and our practice has been to limit the quantity of sand to 25 per cent., which gave very good results. I think, for high speed track, anything in excess of that would make a dusty track.

Mr. Willard Beahan (Lake Shore & Michigan Southern):—Permit me to supplement the remarks of our chairman and relieve him from doing all the talking. I happen to be one of the gravel sharks on this Committee, and the results, when we came to test gravel with the screen, were surprising to me. There is more sand in gravel than one would think. If you should screen it you would be surprised at the result. I did not suppose I would ever advocate 40 per cent. sand. We arrived at it in this way: We mixed the gravel up, and considered how it compared with the gravel from our washers and our pits, and that percentage represents simply the practical judgment of the gravel men on your Committee. It is not the sand that has so much damaged our gravel. It is a little film of clay that surrounds each particle of gravel, and that is the thing that damages our pit, our own gravel. It is the clay wash. We should not need to wash gravel at all if it was simply the sand to be removed from it. You would be surprised to find out the great amount of very fine material there is in pit-run gravel, not altogether clay, but sand, that is so small there is no grit to it at all, just like flour or dust. The parts of the pit-run gravel which ruin it for ballast are rather a small percentage of the total amount. That percentage (40 per cent.) was arrived at by observation and inspection, after we had screened it carefully. I suspect, if you gentlemen would take the screens and screen as carefully as Mr. Paquette did, you would find results that would surprise you somewhat. So it is what we *wash* away from our pit-run gravel that helps the washed gravel. It is not what we *screen* away as sand.

We do not pick up *sand* on our trains. On the Lake Shore Railroad, what we pick up, which is such a nuisance to trains, is a fine, impalpable powder which washing removes.

I want to say a word as to the difference between gravel and sand. The idea of the Committee was that that old definition did not define at all. It simply said sand was finer than gravel. You can turn it around and say that gravel is finer than sand, and what do you know more than

upper limit of size for broken stone ballast, then I think it would do very well for gravel ballast also. There can be no objection to making the limit an arbitrary one, seeing that we can find no limit at all if we seek to establish it upon any other basis. As Mr. Hanna well says, there is no line drawn in Nature. If we look to that source for an answer the question becomes just as indeterminate as would be the case to inquire when a pup becomes a dog or when a pig becomes a hog—there is room for variety of opinion. We will waste time if we strive to put a scientific aspect on some of these commercial questions, which can best be settled on practical considerations.

I think these recommendations of the Committee are very important. In the conventions of this Association I have heard—I do not know how many times—the question come up in this way: Someone would express an opinion as to a proper limit on the proportion of sand in gravel ballast, and right away some inquisitive fellow would propound the question: "Well, what is sand, and what is gravel?"—and there we were. No one seemed to know exactly what he was talking about, because he could not give accepted definitions of the terms he was using. Necessarily there must be definitions for these materials if we wish to discuss them intelligently. The Association must have some standards to go by. When ballast containing such and such proportions of gravel and sand is referred to in our proceedings the Association is compelled to define what sand is and what gravel is; and in these definitions of the Committee the thing is done. In my mind the only question is whether the numbers of the screens which place the lower and upper limits on these materials are of the proper mesh, and inasmuch as the Committee has given it a good deal of study, I assume they have made selections of about the proper degree of fineness. I agree with the Committee, except that I think it would be better if the definition for sand stood by itself without reference to gravel, and if the definition for gravel stood by itself without reference to sand. I favor drawing a line sharply between them, just as the Committee does.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—There is another Committee which will probably consider the definition of sand, and it is possible they may have already recorded themselves in the Manual, and that is the Committee on Masonry. Are we to understand that this definition of sand applies to ballast only, or if we adopt it to-day, will it be applicable to sand for use in concrete and masonry also? For my own part, I would be perfectly willing to see it stand for both uses, as amended by Mr. Lindsay.

Mr. Hanna:—Our Committee looked at this from the ballast point of view only. I think, if the definition is to stand for sand for use in masonry, the Masonry Committee ought to have something to say. We do not claim to speak for them.

Mr. McDonald:—Then they should define sand for ballast.

Mr. L. C. Fritch:—Mr. Lindsay is trying to find the legal definition of gravel and sand and this Committee is trying to point out

to us what would be good practice for the use of certain materials, for a particular purpose. It seems to me the two are separate and apart. I favor the Committee's outline.

Mr. Hanna:—One point Mr. Camp raised, the Committee sees no objection to considering these by themselves, but at the same time even if you look at sand by itself we must keep in mind that gravel is the next thing to it, unless we are going to make another division of ballast material and call it something else.

Mr. Lindsay:—I think in defining gravel we should give the primary definition of it as it occurs in Nature, particles of comminuted rock, boulders or pebbles, whatver you may call it, mixed with sand or clay.

The President:—The question is on the definition of sand. Mr. Lindsay's amendment is to eliminate the words "finer than gravel" and to add "will pass through a No. 10 screen," so that the amended definition would read: "Any hard granular comminuted rock which will pass through a No. 10 screen and be retained upon a No. 50 screen."

(Motion carried.)

The President:—The amendment is carried, and the definition of sand will be according to Mr. Lindsay's amendment.

Mr. Camp:—That suits me first rate for the definition of sand. Now I make a motion that the definition of gravel be adopted as it stands.

(Motion carried.)

Mr. Hanna:—I believe it is in order to offer a motion with reference to the conclusions on page 160, of Bulletin 107. I would move that the conclusions offered by the Committee be adopted.

Mr. Ewing:—I second the motion.

Mr. J. O. Osgood (Central Railroad of New Jersey):—I would like to ask why, in stating proportions of gravel and sand, it is thought best to make them specific and not to state that the amount of sand shall not exceed a certain percentage? It would naturally occur to me that in specifying gravel it would be desirable to have it as clean gravel as possible, and limit the amount of sand, and certainly it would be so in regard to some gravels, even under the specification of the Committee. It might be wiser to say the proportion of sand shall not exceed a certain amount than say it shall be such an amount, as is specified here.

Mr. L. C. Fritch:—I would like to amend the motion by changing class A to read, instead of 40 per cent., a maximum of 35 per cent.; for class B, a maximum of 50 per cent., instead of 60 per cent.

Mr. Maurice Coburn:—I agree with Mr. Fritch in his recommendation. On our road we pick up with our fast trains a very large part of the material which is classed as sand by the Committee. I do not think our trains run any faster than those on the Lake Shore. We have gathered some samples, and I am pretty sure of what I am talking about.

Mr. Hanna:—I believe that Mr. Fritch is under a misapprehension with regard to the Committee's proportions. Ten parts of gravel and three parts of sand would make 13 parts in all, so the three parts sand

is little less than 25 per cent. I confess I think it would be better to put it in the shape of percentages.

Mr. M. L. Byers (Missouri Pacific):—In regard to washed river gravel, there should be a minimum. The river gravel, with insufficient sand in it, acts much like shelled corn, and it is impossible to keep the track in proper shape. We have had some experience with that, with some gravel, that I think contained about 15, or possibly 20 per cent. sand, and we have had a good deal of trouble to maintain the track with that material. Since that we have increased the percentage of sand and find the result very much better.

Mr. Beahan:—Now, if the gentlemen who are talking sand and gravel would wash their material, the results would be different. You hear all sorts of reports. "You pick up sand." You don't pick it up. We can't pick it up with the Twentieth Century Limited at 100 miles an hour. We have washed it and leave a certain percentage of sand in the ballast and find our trains pick up nothing. What is the use splitting hairs on 5 per cent.? Did you ever see a gravel washer that could run within 5 per cent.? You cannot do that. Again, as to rolling of track on the washed ballast. Our trainmasters talked of this, but our roadmasters never. Our track ballasted with washed gravel does stay in line. It is academic to say washed gravel causes ties to slide on the ballast. When we wash our gravel in some of our pits we have to waste 40 per cent. in order to get down to the screen we are using; in another about 70 per cent. Of course that is exceptional. We have another pit where it will produce 90 per cent. of washed gravel. But take the coarsest of it; we have never had a track go out of line one particle. There may be gravel that will roll under the ties, but we do not have it in this part of the country. The trouble we have is to get the clay out of the pit-run gravel, and we have to wash it out. There may be something like torpedo gravel. Many of these things are academic; and, carrying out the simile, if you will take it into your laboratory and screen it you will find the material is quite different, and you will find the percentages different. This upper limit of gravel is put there for a purpose. In running our washers, when we get a piece of gravel, a cobble that is too big to go through that ring, we crush it, and if by accident we do not get it crushed fine enough, we crush it again, and we do not allow anything to get into it that will not go through, so we fix the limit for sizes of particles for gravel, both upper and lower limits, with our screens.

Mr. Coburn:—I think there is some difference between the pit gravel, such as we have, and such as they have on the Lake Shore, and the river gravel, such as some of the roads west of the Mississippi River have, and those using Mississippi river gravel have. I will say to Mr. Beahan that we have screened our gravel and have made some laboratory tests.

The President:—The question is on the amendment to change the percentage on the class A roads from 40 per cent. to a maximum of 35

per cent.; on class B roads from 60 per cent. to a minimum of 50 per cent.

Mr. Hanna:—I would not like to see it go through in exactly that form. I think in view of what Mr. Byers has said about his experience—and others have had the same—that we ought to have a maximum and minimum limit, and before the convention finally settles on this, we ought to have the experience of other roads and know what their minimum limit has been, what has proved to be a good minimum limit. Then I think we would better rewrite this, so that the whole recommendation will be expressed in percentages and not in parts. The Committee will do that.

Mr. H. R. Safford (Illinois Central):—Our experience in Mississippi river gravel has taught us that a maximum of 35 per cent. and a minimum of 28 per cent. sand are proper limits. We started out with a specification of 25 per cent., but found that not sufficient, and gradually increased it to 35, and with that character of gravel we find no trouble with the sand being picked up by moving trains. Our recommendation would be a minimum of .28, maximum of 35.

(Mr. Fritch's motion was lost.)

Mr. Hanna:—I do not like to see the thing drop there, and prefer to get a more definite expression of the convention on the maximum and minimum question. I would like to have a vote that will fix those two limits.

Mr. Camp:—Do I understand from the Chairman that he does not wish to see the recommendations go through as they stand?

Mr. Hanna:—Since the discussion here it has occurred to me that our own statement of it is not exactly satisfactory, and, speaking for the Committee, I would like to make a change in it. We think our maximum is all right, but we have not stated a minimum and stated it clearly.

Mr. Camp:—Can we not fix it up right now? Take Mr. Safford's maximum and minimum figures, and see if the convention will adopt them.

Mr. M. L. Byers:—I would like to move this amendment, that for washed river gravel, the per cent. of sand shall not be less than 25 per cent.

Mr. Beahan:—May I ask why you put in the word "river"?

Mr. M. L. Byers:—Because there is a difference in the character of the gravel between river gravel, as we find it in the Mississippi river, and some of the streams flowing into that river from the west, and the gravel in the terminal moraines, which is the principal source of supply east of the Mississippi.

Mr. Osgood:—I would like to ask the gentleman whether he intends to fix a maximum as well as a minimum.

Mr. M. L. Byers:—I have not intended to fix a maximum, but a minimum for that peculiar class of gravel.

Mr. L. C. Fritch:—I would rather see this question referred back to the Committee and some further tests made on river gravel and bank gravel.

Mr. M. L. Byers:—With that end in view I will withdraw the motion.

The President:—Do you second Mr. Fritch's motion?

Mr. L. C. Fritch:—I made no motion; simply a suggestion, but I will move, if the previous motion is withdrawn, that the recommendations of the Committee for ballast for the different classes of roads be referred back to it to give us further recommendations.

Mr. M. L. Byers:—I second the motion.

(Motion carried.)

The President:—The Committee on Ballasting is relieved, with the thanks of the Association.

REPORT OF COMMITTEE NO. XIII—ON WATER SERVICE.

(Bulletin 107.)

To the Members of the American Railway Engineering and Maintenance of Way Association:

Your Committee submits herewith the report of its proceedings and work accomplished during the past year.

Meetings were held as follows:

(1) Tuesday, July 7, 1908, at the rooms of the Association in Chicago. Those present were: C. L. Ransom, Robert Ferriday, G. H. Herrold, W. A. Pownall (representing M. H. Wickhorst); A. K. Shurtleff, former Chairman of the Committee, was also present.

J. L. Campbell, J. P. Congdon and C. A. Morse were also heard from by letter in reply to a preliminary report sent out by the Chairman June 26, 1908.

Mr. Ferriday was asked by the Chairman to draw up a draft of a report on "The Methods of Delivery of Water to Locomotives."

(2) Tuesday, September 1, 1908, at the rooms of the Association in Chicago. Those present were: C. L. Ransom, W. A. Pownall (representing M. H. Wickhorst), Robert Ferriday, L. P. Rossiter; A. K. Shurtleff, former Chairman of the Committee, was also present for a short time.

J. L. Campbell, J. P. Congdon, G. H. Herrold, E. G. Lane and C. A. Morse were also heard from on a list of questions sent out by the Chairman under date of July 16, 1908.

(3) Friday, November 6, 1908, at the rooms of the Association in Chicago. Those present were: C. L. Ransom, W. A. Pownall (representing M. H. Wickhorst), Robert Ferriday, G. H. Herrold; A. K. Shurtleff, former Chairman of the Committee, was also present for a short time.

L. P. Rossiter and J. L. Campbell were heard from by letter.

Mr. Herrold was asked by the Chairman to prepare data on general layout of water stations.

The previous reports of this Committee have dealt largely with the question of water treatment, and the results have been published in the Manual for 1907, pp. 235-239.

In Vol. 2 of the Proceedings, pp. 219-226, the Committee treated the general subject of water service quite fully, but did not recommend any conclusions for the Manual. This general treatment has been consulted in connection with the report of your Committee submitted herewith.

The Committee has no additions or changes to make to the matter already published in the Manual on the subject of water treatment. The attention of the Association, however, is called to the article by Mr. J. L. Campbell, published in Bulletin 91, on "Water Treatment by Electricity." This would tend to show that the question of electrical purification is one that will require further study before it is commercially successful.

It is also the opinion of the Committee that the question of water treatment by distillation should be investigated.

DEFINITIONS.

The question of definitions is one that the Committee has not gone into extensively. The following nomenclature is self-explanatory and generally understood:

PIPE LINES:

- SUCTION LINE—Leading from the pump to the source of supply.
- DISCHARGE LINE—Leading from the pump to the storage tank.
- COLUMN SUPPLY LINE—Leading from the storage tank to water column.

STORAGE TANK, CONSISTING OF:

- FOUNDATION—That portion below ground line.
- SUBSTRUCTURE—That portion resting on foundation and supporting the tub.
- TUB—The receptacle holding the water.
- OUTLET VALVE—The valve in bottom of tub controlling the delivery of water direct to locomotives.
- SPOUT OUTLET—The pipe leading from the outlet valve to the tank spout.
- TANK SPOUT—The movable device for delivery of water from the spout outlet to the locomotive.
- TRACK PAN—Device for taking water while locomotive is in motion.

HISTORICAL.

The attention of the Association is called to the very interesting article by Mr. C. H. Rice on "Historical Notes on Water Supply on the N. Y. C. & H. R. R. R.," published in Bulletin 100. (See Appendix K.)

OUTLINE OF SUBJECT MATTER.

The work assigned to the Committee by the Board covers:

(1) *The relative economy of different fuels used in pumping water, with the relative desirability of each.*

(2) *General principles of water supply service (water treatment not considered) and typical installations for various conditions.*

(3) *Report on various types of track tanks with designs of typical installations and critical review.*

The Committee has interpreted the second clause to mean that the Board desires the elementary principles of water service to be laid down so as to start at the bottom, for publication in the Manual. This the Committee has endeavored to do and suggests in the report lines for further investigation in later reports.

(1) RELATIVE ECONOMY OF DIFFERENT FUELS.

The different fuels used by railroads in pumping water are as follows: Coal, Gasoline, Kerosene, Distillate, Fuel Oil, Artificial Gas (from municipal plants or gas producers), Natural Gas. Compressed Air and Electric Power are also used where obtainable from other plants or where duty is great enough and conditions favorable to their use.

Circulars were sent out by last year's Committee to all members of the Association, requesting reports on the relative merits of the different fuels. Twenty-four replies were received; of these, ten were considered of sufficient reliability to warrant tabulation. From these reports, which are given in Appendix A, deductions were arrived at as follows:

(1) That gasoline and coal are the only fuels that were in common enough use *at the present time* to enable a report on their relative economy for railroad pumping plants to be made by the Committee. The Committee recommends that further investigation be made as regards the use of Kerosene, Distillate, Fuel Oil, Artificial Gas, Natural Gas, also Compressed Air and Electric Power.

(2) That the reported actual consumption of fuel by the average railroad pumping plant is larger by several times than the amounts which should be consumed according to the tests of machinery on the testing floor. This is due to several causes, viz., the small size of plant, causing the percentage of efficiency to decrease; careless and inefficient employés; careless and inefficient manner in which accounts are kept.

(3) That the actual fuel consumption per effective horse-power per hour was as follows:

Number and Description of Tests.	Amounts per Effective Horse-Power per Hour. Up to 50 E. H.P.	
	*Coal Used, Pounds.	Gasoline Used, Gallons.
	10 Tests Effective H.P. From 1.37 to 4.61.	24 Tests Effective H.P. From 0.51 to 4.67.
Maximum....................	67.	0.98
Minimum....................	30	0.24
Averages of All Tests..........	50.	0.50

*Coal ran from 14,000 to 10,000 B. T. U. per lb.

On larger plants, for which only a few tests have been received, the amounts per E. H.P. are considerably less, although the ratio remains about the same.

In conformation of the above tests, 240 circulars were sent out to members of the Association and the replies received thereto indicate that the conclusions as to the relative amounts of coal and gasoline used are correct.

In connection with this conclusion, the attention of the Association is called to the article on the relative value of coal and gasoline as a fuel for railroad water stations, by Mr. A. K. Shurtleff, former Chairman of this Committee, as published in Appendix H of this report. This article is a very valuable contribution to the information existing on this subject, and as it is the result of long and practical experience and is very ably prepared, it has been used as a basis by the Committee in the calculations for size of pumping plants.

The conclusion is therefore arrived at that 100 lbs. of coal will do the same work as one gallon of gasoline; or coal at $3 per ton unloaded in the pumphouse bin is equivalent to gasoline at 15 cents per gallon delivered in the gasoline storage tank.

The relative cost of repairs and depreciation of steam and gasoline plants is a question on which the Committee has not been able to get very definite figures. The figures obtained, however, and given in Appendix B, indicate that there is not a great deal of difference.

Appendix B-1 is also submitted, showing the actual cost of repairs to gasoline plants per one thousand gallons pumped. The road giving this information has very few steam plants, and figures on steam plants as a comparison were not obtainable.

It is difficult to arrive at a definite conclusion as to the question of labor. Local conditions govern largely and the Committee believes that with plants of the same capacity the labor charge would be the same with coal as with gasoline. This conclusion is arrived at for the reason that the Committee does not wish to recommend that a gasoline engine be left to run itself without intelligent supervision, and it *should have* nearly as much as a steam plant *has to have.*

In conclusion, the Committee would recommend that the selection of *steam* as a motive power be made in accordance with the following conditions:

(A) Where 100 lbs. of coal unloaded into a pumphouse is cheaper than one gallon of gasoline delivered in gasoline storage tank, taking into consideration the number of hours the plant is to be operated and the location of plant as regards delivery of fuel; special attention also being paid to the proper design of pump as regards size of steam and water cylinders on large plants.

(B) Where a steam plant is maintained for other purposes, as at terminals where shops are run by steam.

(C) Where interest charge on plant is less than it would be on a gasoline plant.

The selection of gasoline as a motive power should be made in accordance with the following conditions:

(A) Where one gallon of gasoline delivered in gasoline storage tank is cheaper than 100 lbs. of coal unloaded into the pumphouse, special consideration being given to locations remote from trackage and isolated stations where train service is such that pumper can, by pumping the whole of his time between trains, do the pumping at two or three stations.

(B) Where the quality of the water is such that it will necessitate heavy boiler repairs, provided boiler compounds cannot be successfully used.

(C) Where interest charge on plant is less than it would be on a steam plant.

GENERAL PRINCIPLES OF WATER SUPPLY SERVICE AND TYPICAL INSTALLATIONS FOR VARIOUS CONDITIONS (WATER TREATMENT NOT CONSIDERED).

The general principles of water supply service can best be considered by taking the following subdivisions separately:

(1) Quantity of water required.
(2) Sources of supply.
(3) Method of gathering supply.
(4) Pumping plants.
(5) Method of delivery to locomotives.
(6) Typical installations.
(7) Methods of operation.

(1) *Quantity of Water Required.*

This should be carefully considered in accordance with the following subdivisions:

(A) Amount at terminals.
(B) Amount per train mile.
(C) Capacity of tanks.

The Committee recommends that further investigation be made as to the quantities of water required under the above headings for the various classes of traffic recognized by the Association.

(2) *Sources of Supply.*

All waters should be chemically analyzed and this analysis considered in connection with the decision on source. The data on water treatment heretofore published in the Manual should be referred to in making this analysis.

The Committee recommends that a supply be obtained, if possible within economical limits, sufficiently large so that the total amount of water likely to be required during the average volume of business in

twenty-four hours can be drawn from the source in four hours at intermediate stations and in seven hours at terminal stations.

CITY WATER.

Where water can be purchased at an economical figure and in sufficient amount and of suitable quality, this source of supply is recommended above all others.

SPRINGS.

Springs usually furnish a supply free from sediment. Careful gagings should be made as to the flow of springs over a period of at least one year, and the possibility of future increase considered, before they are adopted as a permanent source of supply.

LAKES, NATURAL PONDS, CREEKS OR RIVERS.

These sources are subject to pollution by organic matter and may carry a large amount of sediment.

SURFACE PUMPED WELLS

Dug Wells.—A method of collecting supply where water-bearing strata are of a thick and slow filtering material. The limit of depth to be determined by the necessity of supply and expense involved.

Surface Pipe Wells.—This is a method of collecting supply where water-bearing strata are porous and heavily charged with water, which stands within suction distance of pump location. The screens, points or strainers may be subject to corrosion or incrustation, but are easily repaired. This type of well has the advantage of affording additional supply by the construction of additional wells.

ARTESIAN WELLS.

If obtainable, this source of supply is desirable, especially if the water on reaching the surface has sufficient head to force itself into the storage tank.

DEEP WELLS PUMPED.

This class of well is a last resort and should never be used when any other system can be devised at anywhere near a reasonable expense. The deep wells are very expensive, both as to construction and maintenance, and are generally out of service a portion of the time undergoing repairs.

METHOD OF GATHERING SUPPLY.

Springs.—The style of construction of reservoir or intake is largely a matter for local consideration. Springs should be covered so as to keep out organic matter. If the spring is at a suitable elevation, so that a gravity supply can be arranged, and there is no danger of shutting off the supply, and the character of the ground will permit, it is well to excavate and wall the spring to serve as a collecting reservoir.

Lakes, Natural Ponds, Creeks or Rivers.—These sources require special investigation for each case. In making this investigation special

consideration should be given to future pollution, sediment and riparian rights.

The existence of organic matter in excess will cause foaming and is to be avoided, as it cannot be removed by any practical process.

The existence of sediment involves the construction of a filter or a settling basin. The question of filters is a problem in itself and the Committee recommends that it be taken up as a separate subject in later reports. The size of settling basins is the principal thing to be determined and the following data are required:

(1) How long does the water have to stand at different depths at the time of year when it contains the most sediment in order to clarify.

(2) Maximum quantity of water to be used in 24 hours.

(3) Topography and character of soil at proposed location to determine whether basin can be on top of ground or submerged.

The location of settling basin above the natural ground facilitates the cleaning out of the sediment, and when same can be combined with the storage tank, a very cheap and satisfactory solution of the matter is found. This combination avoids the necessity of a second pumping plant where the initial pumping plant is of such a character as will handle water carrying sediment.

The location of settling basin below the natural ground generally permits the unclarified water to enter by gravity and only the clarified water is handled by the pumping plant. It should be so constructed as to exclude any undesirable ground waters. It has the disadvantage of requiring cleaning.

Dug Wells.—No dug well should be started until careful tests have been made at the proposed site with an auger to determine probable depth and character of water-bearing strata. The size of the well required will depend upon the porosity and thickness of the water-bearing strata, no definite rule for which can be given. For locomotive service the minimum inside diameter should be 8 ft., with 18 in. walls, and the maximum diameter should be 30 ft., with 30 in. walls. The material for walls may be brick, rubble stone or concrete. The latter is the preferable on account of its being more readily tied together with rods, so that it will not part in sinking. The portion to be located in the water-bearing strata should be perforated with holes made by building pipes into the wall. If rubble or brick is used it can be laid dry for the portion which will be located in the water-bearing strata and in cement for the balance. The caisson, or cutting edge, should be a wedge-shaped shoe built up of 3 in. or 4 in. plank the same height as the width of the wall. A sheet iron cutting edge should be added where hard, tough clay, boulders or timber are likely to be encountered. In this caisson, or cutting edge, should be fastened ⅞-in. to 1 in. round iron anchor rods, not over 2 ft. center to center, and extending from top to bottom of wall.

Surface Pipe Wells.—The drawing in Appendix F shows the style of pipe wells recommended and gives the details of construction. These can be located close to the pump, or each other, or at some distance and scattered over a large area where necessary, in order to get a sufficient supply of water.

Deep Wells.—The construction of artesian deep wells and pumped deep wells is the same, with the addition to the latter of working or pump barrel, drop pipe and pump rods, and is shown in Appendix G. Before the construction of a deep well is begun, investigations should be made of all wells in the vicinity to determine the probable depth and strata to be passed through. It is also well to consult the Government Geological Charts, where any exist, as valuable information can frequently be obtained from them. The depths of the various sizes of pipe can, of course, only be determined as the well is put down. It is recommended that where the depth is expected to reach 500 ft. or more and no reliable data are on hand in regard to the strata to be passed through, that a start be made with 12 in. pipe. The use of a drop pipe in all pumped deep wells is recommended. In the completion of a pumped deep well it is recommended that the drop pipe be first lowered so that the cylinder is just submerged and then tested for capacity of well. If this proves insufficient, lower another length, and retest, and continue this until the desired supply is obtained. In this way the size of the pumping plant can be more readily determined.

PUMPING PLANTS.

The size of plant is the first question to be considered. The Committee recommends that if sufficient water is obtainable the plant should be of such size that the amount of water as shown by the following table can be pumped:

Quantity per 24 Hrs. in Gallons.	Terminal Stations.		Intermediate Stations.	
	Time Pump to Run in 24 Hrs.	Gallons per Minute.	Time Pump to Run in 24 Hrs.	Gallons per Minute.
2,000,000	20 Hours	1,666	20 Hours	1,666
1,750,000	20 Hours	1,458	20 Hours	1,458
1,500,000	20 Hours	1,250	20 Hours	1,250
1,250,000	20 Hours	1,042	20 Hours	1,042
1,000,000	20 Hours	833	20 Hours	833
900,000	20 Hours	733	20 Hours	733
800,000	20 Hours	666	20 Hours	666
700,000	20 Hours	583	20 Hours	583
600,000	20 Hours	500	10 Hours	1,000
500,000	7 Hours	1,189	10 Hours	833
450,000	7 Hours	1,071	10 Hours	750
4000.00	7 Hours	928	10 Hours	666
350,000	7 Hours	838	10 Hours	583
300,000	7 Hours	714	10 Hours	500
250,000	7 Hours	595	4 Hours	1,041
200,000	7 Hours	476	4 Hours	833
150,000	7 Hours	357	4 Hours	625
100,000	7 Hours	238	4 Hours	416
50,000	7 Hours	119	4 Hours	208
25,000	7 Hours	60	4 Hours	104

At plants where it is necessary to run twenty hours duplicate machinery should be provided.

The quantity of water to be delivered having been decided upon the next question that arises is the size of discharge pipe needed. The following formula is submitted for this determination. The constants given will vary slightly with local prices, but the percentage will be so small that this feature can be neglected:

Method to Determine Economical Proportion of Discharge Pipe Lines.

C = Cost of main per lin. ft. laid, assumed as follows, with pipe at $25.00 per net ton: 4 in. at 65c, 6 in. at 80c, 8 in. at 95c, 10 in. at $1.20, 12 in. at $1.50, 14 in. at $2.15.

I = Interest on one dollar for one day at 6 per cent. per annum = $0.000164.

P = Cost of fuel only to raise 1,000 gallons of water 1 ft., assumed at $0.0003 per 1,000 gallons, on a basis of coal at $2.00 per ton, or gasoline at 15c per gallon (from actual tests).

Qd = *Average* quantity of water to be pumped per 24 hours in 1,000 *gallons.*

Qm = Gallons per minute plant is to handle.

H = Friction head in feet for 1 ft. of pipe for quantity of water plant is to handle per minute.

D = Inside diameter, cast-iron main.

D = is economically proportioned where the interest cost of pipe investment per day = daily cost of fuel overcoming the friction head, or:

$$I \times C = P \times Qd \times H.$$

Substituting for C, I and P the values assumed above and solving for Qd and H for different sized pipes, the following is obtained:

Use 4 in. Cast-Iron Pipe where $Qd \times H = 0.355$
Use 6 in. Cast-Iron Pipe where $Qd \times H = 0.437$
Use 8 in. Cast-Iron Pipe where $Qd \times H = 0.519$
Use 10 in. Cast-Iron Pipe where $Qd \times H = 0.656$
Use 12 in. Cast-Iron Pipe where $Qd \times H = 0.820$
Use 14 in. Cast-Iron Pipe where $Qd \times H = 1.162$

The number of gallons per minute, size of discharge pipe, and static head being known, we can determine the *effective horsepower.* The various tables for friction in water pipes can be used in substituting in the above formula and in determining the friction head. It is well to add about 50 per cent. to the friction head, as per tables, in calculating the friction head for the proposed plant to provide for incrustation of pipe lines, especially if the water to be pumped has been treated.

The following formula is a short method of obtaining the Effective Horsepower (E. H.P.):

$$\text{E. H.P.} = \frac{\textit{Gallons Per Minute} \times \textit{Static Head and Friction Head in Feet.}}{4{,}000}$$

The 4,000 should properly be 3,960, but the former figure is sufficiently accurate for practical purposes.

The only style of plants to be considered in this report, as before stated, are steam and gasoline.

BOILERS.

Where steam is used as power the question of the most economical boiler must be considered. This is a question which the Committee has not been able to analyze as thoroughly as it is thought it should be, and it is recommended that this question be gone into more thoroughly by future committees, especially for small plants, 5 to 25 H.P. The types which seem to find the most favor are the locomotive firebox type, manufactured in sizes 15 to 25 H.P., and the vertical submerged flue type, manufactured in sizes 5 to 50 H.P.

Other types may be used as follows:

Horizontal Tubular or Return Flue.—Manufactured in sizes from 10 to 150 H.P. These require a brick setting, but are believed to be more economical in fuel consumption than those in general use. There is a portable boiler of this type manufactured in sizes 4 to 25 H.P., which should be investigated.

Vertical Tubular-Full Length Tubes.—Manufactured in sizes 5 to 50 H.P. The particular merits of this not investigated.

Vertical Single Flue.—These have advantages in the repair item and not requiring as constant attention as tubular boilers. Their merits as to economy are not investigated.

Internally-Fired or Scotch.—Manufactured in sizes 10 to 100 H.P. The relative merits of this type have not been investigated. They are used largely in marine work and great economy is claimed.

Horizontal Water Tube.—These require a brick setting. Where plants are of sufficient size they might be useful.

Vertical Water Tube.—These also require brick setting. In large enough plants great economy is claimed.

The following items should be taken into consideration in the selection of a boiler: Kind of water, kind of fuel, location of plant as regards availability of labor for repairs, and size of plant.

Boilers should be constructed to carry 100 lbs. pressure for Railroad Pumping Plants. Assuming this 100 lbs. as boiler pressure with a reasonable layout of piping, we would get about 90 lbs. pressure in our pump cylinders. From the formula previously given the E. H.P. has been obtained. Assuming the pump efficiency as 66⅔ per cent., the I. H.P. will be 50 per cent. more than the E. H.P. In order to obtain the size of boiler required, the amount of water necessary to be evaporated must be obtained. Using the diagram No. 1 by Mr. Shurtleff, Appendix H, the pounds of feed water at 65 degrees F.—Equivalent Evaporation from and at 212 degrees F., required per I. H.P. hour for the assumed value of cylinder pressure (90 lbs.) is obtained at 44 lbs. Multiplying this 44 lbs. by the I. H.P. gives the total pounds of feed water at 65 degrees to be evaporated.

One sq. ft. of boiler heating surface is, according to the Am. Soc. of M. E. Standards, capable of the evaporation of 3.45 lbs. of water from and at 212 degrees F. This is known as the standard evaporation or W. In order to obtain the number of pounds of feed water at 65 degrees F. (the assumed temperature) which can be evaporated and made into steam at 100 lbs. pressure (the recommended boiler pressure) the following calculation is necessary:

To evaporate 1 lb. of water under atmospheric conditions from and at 212 degrees F. requires 965.66 B. T. U.

Feed water at 65 degrees contains 33.12 B. T. U. = h.

Steam at 100 lbs. pressure has a temperature of 316 degrees and contains 1,178.3 B. T. U. = H.

Therefore we will require $W \div \frac{H - h}{965.66}$ = pounds of water per sq. ft. of heating surface which can be evaporated from 65 degrees F. to 100 lbs. steam pressure.

Inserting the values of H and h the equation becomes:

$$3.45 \div \frac{1{,}178.3 - 33.12}{965.6} = 3.45 \div 1.193 = 2.88$$ lbs. of water evaporated per sq. ft. of heating surface with feed water at 65 degrees F. to steam at 100 lbs. pressure.

The total water to be evaporated divided by this 2.88 lbs. gives the sq. ft. of heating surface required for the boiler. To this should be added 25 per cent. for contingencies, such as poor fuel, lower feed water temperature, poor insulation of boiler and piping, etc.

Most boiler manufacturers list their boiler as a certain number of H.P., and in the majority of cases this H.P. rating is based on 10 sq. ft. of heating surface per H.P. of boiler, so that the square feet of heating surface of any boiler is readily found. Where the boilers are not so listed it will be necessary to calculate the heating surface in the boiler proposed.

Appendix I gives in tabular form the boiler horsepower required for assumed conditions per E. H.P. from 1 to 15 for vertical and locomotive type boilers.

The ratio of grate area to heating surface varies considerably with the size and kind of boiler, and as this is always given in boiler catalogues and is a detail of boiler design it is not gone into in this discussion. The questions of water heaters, boiler feed pumps, injectors, stacks and all details of boiler design have not been considered by the Committee.

Gasoline Engines.—Where gasoline is used as power, on account of the high speed of gasoline engines, it is always necessary to reduce this speed by means of geared or belted connections for the operation of the pump. The Committee recommends that gearing having cut teeth

in preference to belting be used for this purpose and that a friction clutch be introduced in order to be able to start the engine with no load; all of this machinery to be mounted on one substantial base and foundation with the engine so as to prevent same getting out of line. The power should then be transmitted to the pump by a shaft making the same speed as the pump. In this way the pump can be set some distance from the engine, this generally being desirable on account of location of pumps in pits. This layout avoids the troubles incident to a high-speed shaft getting out of line.

Gasoline engines are usually sold on a brake horsepower basis. In order to obtain the proper size we should add 100 per cent. to E. H.P. for friction in pump and for safety factor. This is based on 66⅔ per cent. efficiency in the pump and gearing and using 75 per cent. of the power of the engine.

There are in general two different classes of pumping plants, viz., Surface Pumping Plants and Deep Well Pumping Plants.

SURFACE PUMPING PLANTS.

These are plants where the suction lift is such that the pump cylinder can be placed at the surface of ground or in a pit of moderate depth.

Surface Steam Pumps.

Where steam is used as a motive power the duplex, simple steam expansion, double-acting pump seems to be the most largely used, and it is believed to be the most economical for the size of plant generally used in railroad pumping plants. No figures were obtainable for other types of pumps, as this is the kind generally used. The size of water cylinder is obtained from the quantity to be pumped per minute, assuming 70 strokes or 35 revolutions per minute for each cylinder. The efficiency of pump should not be taken as over 66⅔ per cent.

The ratio of water to steam cylinders should be as large as practicable. The boilers, as before noted, should be constructed to carry 100 lbs. pressure. With this and a reasonable layout of steam piping we can get 90 lbs. steam pressure in cylinder. Assuming this initial cylinder pressure and knowing the total water pressure we obtain pounds cylinder pressure and knowing the total water pressure we obtain pounds of cylinder pressure per pound of water pressure. Using the Diagram No. 4, Appendix H, by Mr. Shurtleff, we obtain the highest ratio of water to steam cylinder possible for the assumed efficiency of 66⅔ per cent. Then from Diagram No. 3, knowing the size of our water cylinder, we obtain the size of the steam cylinder.

Power Pumps.

In the case of gasoline, where pump and engine can be placed on the same level, the triple single-acting, duplex double-acting and for small plants the combined engines and pumps are very desirable devices. Where the pump must be at a lower level than the engine the double-

acting single cylinder connected to shaft by means of face plate and pitman should be used. This face plate should be provided with several different wrist pin poles so as to vary the length of stroke. The following lengths of pitman and strokes per minute are recommended, based on the stroke length as four times the length of the stroke with a minimum length of 6 ft. and a piston speed of 70 ft. per minute:

For	Stroke	12 in.,	Pitman	Length	6 ft.,	No.	strokes per	minute,	70
"	"	18 in.	"	"	6 ft.,	"	"	"	46
"	"	24 in.	"	"	8 ft.,	"	"	"	35
"	"	30 in.	"	"	10 ft.,	"	"	"	28
"	"	36 in.	"	"	12 ft.,	"	"	"	23

The piston speed above given is much less than that generally quoted in pump catalogues, but is the recommendation of an old and experienced pump manufacturer.

The design of the pump should be such that the pitman cross-head guide rods are perfectly rigid, top and bottom, and large enough to prevent any lateral motion of the cross-head and consequent piston wear. The foundation for the pump and face plate should be designed so that both will be perfectly rigid. It is well to use I-beams anchored in the side walls of the pump pit for both. The pump can be anchored to these by use of a bar underneath, with long bolts through the pump base and bar, thus avoiding drilling of holes in I-beams and rendering the lining of pump to fit the shaft a simple matter.

DEEP WELL PUMPING PLANTS.

These are plants where the suction lift is such that the pump cylinder or working barrel has to be placed inside of pipe well at a considerable distance below the surface of the ground so as to render the construction of a pump pit impracticable.

Appendix G shows the layout below the floor of pumphouse, and this is analyzed under the head of "Deep Wells." The steam pumping plant seems to give the best satisfaction for this class of well, for the reason that its operation is without the shock attendant on the operation of a rigidly connected gasoline engine outfit, although the latter are successfully used in many plants.

The steam head, or artesian well pumping engine, as it is generally called, is made in various sizes. The stroke varies from 18 in. to 36 in. The 36 in. stroke is the one generally used where water supply is sufficient. These engines should be provided with displacement plungers in order to keep flow of water uniform and prevent shock. They should also be so designed that the engine can easily be removed and disconnected from the pump rod to facilitate working barrel repairs.

The size of the deep well pumping engine cylinder can be obtained in the same manner as described under the head of "Steam Pumps."

The piston speed of this class of pump should be 60 ft. per minute, making the speeds as follows:

Stroke	12 in.,	No. strokes	per	minute,	60.	No.	cylinder	discharges,	30
"	18 in.,	"	"	"	40.	"	"	"	20
"	24 in.,	"	"	"	30.	"	"	"	15
"	30 in.,	"	"	"	24.	"	"	"	12
"	36 in.,	"	"	"	20.	"	"	"	10

The speed given is much less than that generally quoted in pump catalogues, but is the recommendation of an old and experienced pump manufacturer.

Where gasoline engines are used their size can be obtained the same as before outlined, and the style should be the same as recommended for surface wells with pump below level of pumphouse floor.

PUMPHOUSES.

The pumphouses for intermediate stations should be built of non-combustible material, viz., concrete, stone or brick. The pump pits should be made waterproof, if possible, at reasonable expense. For steam plants a coal storage bin should be provided that will hold at least a car and one-half of coal. The design of this will depend on local conditions in regard to the keeping qualities of the coal and source of supply. For gasoline plants a gasoline storage tank located in a fireproof pit at a distance of at least twenty-five feet from the engine should be provided. The capacity of this tank will depend entirely on the local conditions of supply. The size of pumphouse is dependent on size of plant. It should be well lighted and ventilated. Where there is a pump pit at gasoline plants the engine should be in a room by itself. The engine room should always be ventilated with vents at the floor in order to free the room from gasoline vapor. In no case should gasoline engines be placed below surface of ground.

The question of heat in gasoline engine rooms in cold climates where the operation of the plant is intermittent is one upon which the Committee is divided. The use of a stove is certainly objectionable and the engines can generally be started by the use of hot water carried in from some neighboring house, in the cylinder jacket, so that it seems the safer plan to prohibit the use of open fire in a gasoline engine room. Where steam heat is available it is advisable to install a radiator in the engine room.

In the case of deep wells the pumphouse should be so designed that the portion over the well can be removed or opened sufficiently to allow a well machine to be set over it for use when repairs are necessary.

Pumphouses at terminal stations where used should be designed the same as above. It is generally desirable, however, to incorporate the pumphouse with other shop buildings.

PIPING.

Discharge from pump should always be provided with an air chamber and check valves if same are not incorporated in the pump itself. Connections should be made below frost line with check and waste valve for boiler feed or gasoline engine jacket. In surface pumped plants a by-pass, or priming pipe, from discharge to suction should be provided. In open wells the bottom of suction pipe should have a combination strainer and foot valve. Where pump pits are not waterproof or water is likely to come up over pump at times, a branch suction pipe with a valve having a long valve stem extending above high water should be provided in order to pump down the water in pit.

METHOD OF DELIVERY TO LOCOMOTIVES.

Storage Tanks.—The first comprehensive collection of data on storage tanks which your Committee discovered is given in the 1901 report of Association of Railway Superintendents of Bridges and Buildings, on "Water Stations, Best Material for Foundations, Tanks, Substructures, Connections, Capacity, etc." One hundred and twenty-five circulars of twenty questions were sent to the members; fourteen answers were presented, together with reduced plans of eight. Considerable interest in steel tanks was manifested by the Committee, and that subject received most attention in the discussion. There was practically no data furnished, but the consensus of opinion was that they are economical and will supersede wood. No recommendations, conclusions or Association standards were presented.

The next compilation was made by Committee VI of your Association, in Bulletin 17, March, 1902, and consists of a tabulation of forty-six answers to circulars sent to one hundred railroads, or 55 per cent. of the total mileage requested. The table covers all the parts of the Water Tank and is accompanied by a narration of the features which are collectively similar. Drawings are presented as typical of the designs of foundations, substructures and roofs. Mention is made of steel tanks and discussion requested. No recommendations, conclusions, or Association standards were presented.

ANALYSIS.

Your Committee refers to report of Committee VI to the 1902 convention, before mentioned (see Proceedings, Vol. 3, pp. 163-179), for a full comparison of the designs reported which fairly represent those generally used. Inspection of the tables, together with the analysis preceding them, will demonstrate the great variety of design in which some of the differences are immaterial, others the reverse, both affording good reason for the adoption by the Association of plans recommended as good practice. Illustrative of this: Your Committee finds little extenuation for conditions by which one railroad uses sixteen

12x12 posts and another the same number of 14x14 in the substructure of a 50,000-gallon tub, and holds that such immaterial differences should be harmonized. On the other hand, there is a material difference in designs providing for steel substructure and joists instead of wood. The superiority of the former, from a maintenance standpoint, argues for a recommended practice emphasizing that feature.

Your Committee therefore proposes to submit as recommended practice designs which will serve as concrete examples instead of submitting abstract statements of general principles.

FUNCTIONS OF A WATER STATION.

A water station, as an elementary proposition, consists of a supply of water with means of delivering same to locomotives. This is done by gravity, except with Track Pans, where the same elementary arrangement is present with an added principle for completing the delivery in those special cases.

Where the topography will permit full elevation the arrangement may consist of an elevated reservoir, excavated in the ground, with pipe lines and water columns.

Where only partial elevation can be secured it may consist of a tub resting on the surface with pipe line and water column.

Where the topography will not offer even partial elevation, same must be secured by artificial means, permitting of choice in location of the supply, which is done by placing same (a) near the track, reducing the cost of delivery line, and (b) distant from the track, although at increased cost of delivery line for reasons given later.

The prevailing topography makes artificial elevation necessary at a large majority of water stations, resulting in the structure known as a storage tank, which is subdivided, naturally, into its structural elements on the same lines as those occasioned by varying topographical conditions, viz., Foundation, Substructure, Tub, and Delivery Line.

FOUNDATIONS.

These have consisted mostly of rubble masonry piers finished above ground with dressed pedestals. However, in recent years the use of concrete has become so general that many foundations are now made of that material, and it will probably be most used in the future. It lends itself to economical construction, particularly in this instance, on account of the small quantity required. The form shown on recommended plan is selected as having been found to be cheaply built, the small amount of concrete being mixed wet and placed, without interruption, in the forms which had been made the full size of foundation, centered and leveled before starting.

CONCLUSIONS.

The foundation should be made of any good masonry locally available, provided it also withstands the disintegrating action of water.

It should be carried below frost and as much deeper as necessary to reach firm bearing unless piles or other sub-foundations are used.

The area depends on bearing encountered.

KIND OF MATERIAL.

The material most used in the past has been timber, probably because of cheap first cost and because more quickly available, through the use of sizes usually carried for other work. It is particularly subject to decay on account of prevailing dampness, and the life without heavy and costly repairs will not exceed ten to fifteen years, as a generous estimate, or less than the life of the tub, whereas a moderate estimate of the life of a steel substructure is forty years, or double the life of a tub, without any cost for maintenance except painting, which timber would also receive at about the same cost. The load is static, hence the absence of forces which limit the life of steel by crystallization, together with proper painting, should result in a life far exceeding that given above.

A comparison on the basis of first cost of timber and steel could be made only by means of estimates, as the cost data secured does not show it, and if secured would not be comparable on account of the great variety in design. Your Committee believes your approval of a steel substructure, including joists, can be obtained without going into the detail of this feature by referring in a general way to the following. Most plans for timber substructures of 50,000-gallon tubs call for twelve posts which require twelve foundations, while on the other hand a number of steel substructures have been built with but four posts and a similar number of foundations. The life of a steel substructure is easily four times that of timber at about the cost for maintenance. The scrap value of a timber substructure is very small, while that of steel is large.

HEIGHT OF SUBSTRUCTURE.

The height of substructures in early days, and still to a large extent, has been such as to place the tub just a sufficient distance above the rail to accommodate locomotives taking water with tank spout. The use of water columns and larger locomotive tenders resulted in many substructures being made about twice the former height to reduce the time taking water, and while that was accomplished it might have been done in another way without increasing the head on the pump, for the required discharge "q" is the product of the area "a" of the pipe, and the velocity of water "V," $q = a\ V$, or the discharge varies directly with both "a" and "V." The velocity for head "h" is

$V = \sqrt{2gh}$, in which "g" is the acceleration of gravity. The velocity therefore varies only as the square root of the head, which is best appreciated as follows:

For 16-ft. head $V = 4 \sqrt{2g}$.

For 32-ft. head $V = 5.6 \sqrt{2g}$.

Hence doubling the head only increases the theoretic velocity 40 per cent., which in fact is not obtained, since the friction in column supply line, which must be necessarily considered, increases nearly with the square of the velocity. The other factor "a" varies as the square of the radius ($a = \pi R^2$), while the perimeter varies only directly as twice the radius ($p = 2 \pi R$), or doubling the radius quadruples the area, but only doubles the perimeter or weight of pipe required. When friction is considered the theoretic discharge is further increased, since the friction decreases as the diameter increases. The above may be expressed by the theorem:

Increasing the height of substructure increases the discharge by less than the ratio between the square roots of the two heads; increasing the radius of the pipe increases the discharge by more than the rate between the squares of the two radii.

This theorem, with the friction factors involved, when applied to any situation will enable estimates to be made comparing the *construction* costs of securing the required discharge, but ultimate economy requires consideration of *operating* costs which influence heavily on account of their accumulative effect. The operating factor to be considered is the increased head against which the pump acts when the tub is raised. If "K" is the work performed and "W" the weight of water raised through height "h," then $K = W h$, or the work performed is directly proportional to the head, hence the fuel consumption is affected likewise.

The above principles point out the influence of the variables and the objection to elevating tubs higher than necessary. With regard to actual delivering capacities of water columns under ordinary heads, your Committee have report of careful test of 12-in. column supplied by 14-in. main, which delivered 5,000 gallons per minute under 20-ft. head above column, and have measured the capacity of same sized water column and supply line under 40-ft. head, the time of opening and closing automatic column valve was not included and the tests lasted 45 seconds, taken with a stop watch. The water was delivered at a rate of 6,200 gallons per minute. The conditions surrounding these two tests were not identical, but it will be noticed that the latter had double the head and should therefore have had a theoretic discharge of 7,000 gallons; failure to do so is because of increased loss in friction due to increased velocity before mentioned and perhaps to a difference in the friction factors of the columns. With these discharging capacities we have data for comparing the time required to take water. Assuming 7,000 gallons as the capacity of tender tank and 6,500 gallons as the average quan-

tity taken, the time required would be one minute, eighteen seconds, under 20-ft. head, and one minute, three seconds, under 40-ft. head, or the increased height, 20 ft., or tub saves fifteen seconds. The time swinging column and opening and closing valve is not included above, but the figures are just accurate for comparison, since they are the same for both cases. Where the demand for prompt movement requires consideration of items as small as fifteen seconds while taking water, the traffic is beyond water columns and calls for track pans which avoid delays of much greater magnitude.

The height of substructure has been influenced in some cases by consideration of fire protection, which might have been provided with greater economy and even greater effectiveness by means of a separate fire tower or by fire pumps.

The determination of the height of substructure involves all that has gone before, and in some special cases may involve the largest columns as well as high substructure, but your Committee submits, since columns as large as 12-in. are practicable and sufficient, that the economical arrangement, ordinarily, is a height of substructure which places the tub 15 to 20 ft. above the rail, using a column of such size as will furnish the desired discharge.

DESIGN OF SUBSTRUCTURE.

The number of posts should be as small as consistent and composed of one or two simple, stout shapes rather than of small thin angles latticed together. This will result in fewer foundations, cheaper painting, less surface exposed to corrosion, if neglected, hence less danger in that event with simple, stout shapes than with complex posts of thin angles. This also holds true with the design of the remainder of the substructure.

TUB.

KIND OF MATERIAL.

The material most used has been wood of such suitable kind as was obtainable in the localities where used. White pine has prevailed in the North, cypress in the South, while redwood and fir are largely used in the extreme West. One Northern manufacturer, "A," reports twice as many sales of white pine as cypress in the last three years; another, "B," uses white pine almost exclusively, while another, "C," reports 70 per cent. cypress. The only Southern manufacturer, "D," heard from makes nothing but cypress tubs. Only a limited knowledge of redwood and fir has been obtained by manufacturers "A" and "B," but they believe these materials make first-class tubs and will be used more in years to come, due to growing scarcity of the longer lengths of pine and cypress. Greater care in manufacture and setting is required

of the former, as they do not swell much. It will require the test of time to determine whether they are satisfactory.

The main points of interest in connection with the kind of material are the life based on past experience, the quality of material now obtainable and the trend of prices. Two large Northern manufacturers, "A" and "B," place the life of white pine at twenty years, using about the same modified opinion expressed by "A," as follows: "The length of life of a tub depends almost entirely on local conditions. The lumber and hoops are affected by the water, the tub rots more rapidly if not kept filled and the outside decays and the hoops corrode if not kept painted. We have known pine tubs to last six years and we have known them to last thirty. It would seem to us that a first-class pine tub, well hooped, should last twenty years if kept painted on the outside and reasonably full of water." This manufacturer has furnished about one-third of his output in recent years in cypress, while the other has furnished practically none, and he goes on: "We doubt whether a cypress tub will last longer than twenty years in the Northern climate, due to the fact that it is out of its natural element. Cypress is a water timber, and we believe that taking it out of the water and subjecting it to the wet and dry must affect it in time, so that it will last little, if any, longer than pine. Cypress has the advantage over pine in being clear lumber, and for this reason should last a trifle longer. While we get considerably more money for cypress tubs, we believe for ordinary purposes pine is just as good, although as stated, it may be that cypress gains more by being clear than it loses by being out of its natural element, and it is therefore slightly better than pine. The quality of cypress does not seem to change, but pine lumber is not nearly as good as it was a few years ago. It is impossible to secure at any price a quality of pine which was to be had in the past, as the lumber is not to be had in sufficient quantities for tub purposes."

"B" says: "As to quality of material, would say that it is well known that it is almost impossible now to obtain as good a grade of lumber as in years past, due to the general scarcity, which has also increased the price. For instance, eight or ten years ago we would often receive inquiries for price on tubs, calling for clear material, and while it was hard to get, even at that time, it could be obtained at a price, but now this material is practically unobtainable."

The Southern manufacturer, "D," places the life of cypress tubs at twenty-five years, "if properly cared for," and states that "the quality generally used now is as good as in the past." "C" states his large sale of cypress is "because of the scarcity of No. 1 tank pine lumber. The life of the two is about the same under prevailing maintenance. Railroad companies usually take better care of their pine tubs than they do of cypress, believing that cypress will withstand the effects of the

elements better than pine. Cypress tubs cost about 25 per cent. more than pine." "A" and "B" report higher cost of cypress, but furnish no figures. "B" states it is a well-known fact that the cypress trust holds up the price.

Your Committee believed that the trend of price would be most accurately obtained from the manufacturers, as the matter of quality, freight charges and business conditions in periods of prosperity and depression would render a comparison of prices obtained from the membership of little avail. "A" reports an increase of more than 35 per cent. in the cost of pine and about 20 per cent. in the cost of cypress tubs in the past ten years. While "B" states it is costing him one-third more to-day than fifteen years ago, which he attributes almost entirely to the growing scarcity of proper grade lumber, he states: "Prosperity has not affected the price particularly, although it may have done so to some extent on account of the increased demand for lumber of all kinds. The advance has been gradual and steady and there have been no recessions of any consequence." "C" gives no advice as to increase of price, which is also the case with the cypress manufacturer "D," whose records were destroyed by fire.

The life of any wood is not ended suddenly, hence many tubs serve on, although general decay is evidenced by leaks which foster further decay, interfere with painting and stain the structure. This fact contributes to the variation in the alleged life of tubs. Before passing further and for the purpose of future reference the following conclusion is inserted:

The life of white pine tubs used in the past does not exceed twenty years, the quality used at present is inferior and will have a life of less than twenty years, the price has been increasing rapidly, even with the use of inferior lumber. The life of cypress used in the past does not exceed twenty-five years, the quality at present is as good as in the past. the price has been rapidly increasing. Further increase in the price of wood tubs is to be expected in view of the rapid depletion of forests. The use of wood in tubs limits the capacity of same.

DETAILS.

The use of a water table, band or finish at the bottom of the tub is disapproved, as it fosters decay. The usual thickness of staves and bottom is 3-in. material surfaced to about 2¾ in. This size does not appear too thick, and on the other hand it is doubtful if thicker sizes would be justified, as decay when thoroughly started would allow of but little longer life, due to thicker material.

The following Specifications are submitted for White Pine tubs. They apply as well to Cypress, except that no mention is necessary of plugging small black knots:

SPECIFICATIONS FOR 50,000-GALLON WHITE PINE TUBS.

The inside diameters shall be 24 ft. at the bottom and 23 ft. at the top. The staves shall be 16 ft. long. The tub shall be made of carefully selected white pine lumber, surfaced to 2¾ in. which is free from sap, shakes, unsound knots, or other imperfections which can cause leaks or will impair the durability of the tub. All small black knots extending entirely through the plank shall be carefully bored and thoroughly plugged. All staves shall be full length without splicing. Every joint shall be machine-made and perfect, and the stave joints sawed on true radial lines, with due regard to top and bottom diameter of tub.

The crozing at bottom of staves shall be cut with proper regard for pitch of stave when in position and circular in shape, so as to be completely filled by tub bottom when staves are driven up.

The outside of staves shall be surfaced convex, so as to give a full bearing to hoop throughout the width of each stave.

The tub shall be provided with hoops, as shown on plan, with single bolt pressed steel draw lugs and bolts for tightening.

One extra stave and dowel pins shall be furnished with each tub. Every tub shall be set up at the factory and the bottom and corresponding stave marked and numbered before being knocked down for shipment. The location of the hoops shall also be marked on the staves.

ROOF.

The kind of material used is various. Your Committee consider this to be largely a local problem, involving first cost, maintenance and life of available materials, also that the matter is not vital in this consideration. The kind and design shown on the recommended plan is selected as being universally available, cheap, a good fire risk and of long life, hence fits the situation as well as any which could be used to complete the plan.

HOOPS.

KIND OF MATERIAL.

All the manufacturers report that the railroads generally do not specify the kind of material, one large manufacturer even stating that, "When receiving orders for tubs with 'set of steel hoops,' or 'set of iron hoops,' the part relating to the hoops is usually considered as a general term rather than a definite specification of the kind of material wanted." These conditions, together with competition among the makers, have undoubtedly resulted in placing steel hoops on a large majority of tubs. At present "A" uses wrought-iron exclusively and recommends same, as it is not affected as rapidly as steel by oxidation. "B" uses Bessemer steel and recommends muck bar wrought-iron, but

is of the opinion that steel is preferable to much of the material made of scrap metal of all kinds and sold as wrought-iron. He uses steel on account of its price compared with best grade of wrought-iron and the quality compared with the cheaper grade. "D" uses soft Bessemer steel and recommends iron. "C" states only a few roads require wrought-iron, as most roads specify steel somewhat thicker rather than pay the premium asked for iron. The views above quoted regarding longer life of wrought-iron express those generally held, but hoops of this material appear to be little used on account of the price. Investigation of the cost feature develops, however, that wrought-iron, at present writing, is quoted less than steel, while in 1906 it was but a fraction over 5 per cent. higher. The weight of iron in 12 hoops 4x5/16, all 75.4 ft. long (disregarding taper of tub), is 3,800 lbs. The market of steel at writing is $1.80 per 100 lbs., Pittsburg. Assuming a general price of $2.50 to cover advances and adding 5 per cent. for higher price of iron would make these hoops cost $99.75. Allowing for the tensile strength of steel, one-eighth higher than iron, would make steel hoops cost $83.12, or $16.63 less than iron. This discrepancy reduces when the wearing qualities of each are considered, as heavier steel hoops are required since it corrodes more rapidly, but even disregarding this feature the ultimate cost of the two will be in favor of iron by the time a scaffold is erected and additional hoops added 10 or 15 years later for fear that the experience with other steel hoops may be repeated. The lower quotation on iron is attributed to the decreased demand for wrought-iron and increased use of steel.

SPACING AND SIZE.

It has been the practice to make hoops thin, increasing the section as necessary by making them wider, with slight increase in thickness. The thicker hoops, still being thin and spread out, offer greater surface for corrosion behind the hoops. Thin hoops are used because they fit the staves better, but no matter how close the fit, it is not close enough to exclude the water entirely, and corrosion of wide thin hoops results in materially affecting the strength before the tub has served its life. This results in broken hoops, involving the expense and danger of replacement and, not infrequently, collapsed tubs. The hoops classed as thin are 3/16-in. and 1/8-in. thick, the cross-section of which have been observed by your Committee to consist of mere threads of unattacked metal when removed. Most manufacturers place the maximum thickness at 3/16-in. Your Committee believes the advantage of thicker hoops offsets the merit claimed for thin hoops, particularly as neither will fit into depressions unless hammered, in which event there is not much difference in the contact. No manufacturer has used semi-elliptical hoops, but "B" is inclined to favor them or half-round, provided the roads would agree on a style which would enable him to lay in a stock.

"A" objects because these are not common merchantable shapes and they require forging at the ends. "C" has furnished round hoops, but condemns them on account of crushing the stave and catching water and dirt, while "D" has also furnished round hoops, but offers no objection. The matter of promoting a half-round or semi-elliptical hoop is left to future Committees, as it involves special shapes not ordinarily obtainable and because the increase to $\frac{7}{16}$-in. and the use of iron will be a step in the right direction, which may prove all that is necessary.

The wider the hoop, the better the condition for decay behind it; the narrower the hoop the more expensive on account of more lugs and handling. Four-inch hoops are narrow enough to allow of lugs having but one bolt, which is generally recommended, since with two bolts there is no certainty regarding the strain in either. Pressed steel lugs are considered best by the manufacturers. Four-inch hoops are narrower than those usually used on the bottom half of the tub and about the general width of those used on the upper half. The selection of the uniform size, 4x$\frac{5}{16}$, for all hoops, which is desirable for the sake of reducing the number of sizes, also commends itself for the above reasons. The spacing as shown on the recommended plan is based on a wrought-iron hoop with working area of 4x$\frac{5}{16}$-in., safety factor of 4 and allowable working stress of 12,500 lbs. The $\frac{7}{16}$-in hoop, with this spacing, is proposed to take care of corrosion and still provide safe working conditions which must be guarded, as the tension of bolts, swelling of staves and contraction from cold have not been taken into consideration. With the spacing on the plan the maximum stress in the 2¼-in. stave is in the 9th space from the bottom and amounts to 95 lbs. per sq. in., which makes a safety factor of over 30, as 3,000 lbs. is a conservative value of the ultimate strength of White Pine. Under decayed conditions resulting in only 1-in. thickness of good timber, the stress in the 9th space would increase to 720 lbs., or still be within safe limits. This discussion develops that there is no likelihood of failure of the usual 2¼-in. stave, except from decay, but that the usual $\frac{5}{16}$-in. and ⅜-in. hoops are designed too close, both facts being confirmed by experience. Twelve hoops are required by the above consideration, which is in line with 12 out of 27 roads reported to the 1902 convention; 9 roads use more than 12 hoops and only 3 use less.

The above detail consideration of the usual wooden tub has been developed to guide the preparation of the recommended plan, to inform the Association on matters which could not be a part of such plan and for comparison with steel water tanks. While the comparison with steel is much to the disadvantage of wood, it is believed wood will still be used to more or less extent and that a plan endorsed by the Association will be of value.

STEEL TANKS.

MATERIAL AND LIFE.

The use of steel for tanks at water stations between terminals has not been general and at terminals only to a limited extent, usually when forming a part of a fire or general water supply system; however, in recent years, along with the tendency toward permanence in railroad construction, there has been considerable development along this line and a number of tubs constructed. The life will depend on kind of material and water. The use of metal standpipes for city water supply has extended successfully over a large number of years, which presupposes satisfaction with railroad tanks where the pressure is much less. The metal specified in most of the recent railroad tanks is "open-hearth" steel, and the life of such tanks will depend on the effect of the water. There are without doubt singular cases where the only water available, although corrosive, is used in locomotives, but such conditions are infrequent, will pass with extension of treatment and call for special consideration.

A 16x30 steel tub of ¼-in. and ⅜-in. plates was erected in 1868 in the Forty-seventh Street Shops of the Chicago, Rock Island & Pacific Railway, at Chicago. Although painting was very much neglected, the tub is still in service with the prospect of doubling the present life, since only a shallow depth of pitting has occurred inside, and the outside is now being maintained. The tub was corroded most where it rested on the timber joists. A manufacturer of steel tanks gives as a conservative estimate of the life, five times that of wood, which he places at ten or fifteen years.

TYPES.

The usual form at terminals is a tank with hemispherical bottom, supported by a steel tower. At intermediate stations three types have been developed, viz.: *Flat Bottom Tub* on the usual substructure; *Hemi-ellipsoidal Bottom Tub,* supported by posts around the outside and a cylinder or mud drum, 5 or 6 ft. in diameter, in the center of the bottom; *Standpipe Tub,* consisting of a tub imposed directly on the foundation, the substructure being omitted.

The Flat Bottom Tub requires no explanation. It is merely the application of steel to the usual form of tub. The cost of this type including substructure as constructed on the Nevada deserts under high cost conditions follows:

Date.	Height of Sub.-Str.	Tub.		Cap'y.	Cost.			
		Ht.	Dia.		Mt'l.	Freight.	Erection.	Total.
5–07	50	19	24	65000	1900	273.22	1078.50	3251.72
8–07	13	19	24	65000	1900	462.50	484.58	2847.08
7–07	13	19	24	65000	1900	462.50	638.72	3001.22
8–07	50	19	24	65000	2245	253.80	1000.11	3498.91
4–07	30	....	....	350000	5050	936.00	1927.07	7913.07
10–07	25	....	....	350000	5000	470.80	1250.91	6721.71

The Hemi-ellipsoidal Bottom Tub was developed by the manufacturer from the hemispherical bottom tub, the object being to avoid the expense of joists in flat bottom tubs, to place the tub lower than with hemispherical bottom tubs, thus reducing the head pumped against and to provide a settling space with blowoff valve in the mud drum, which is really part of the bottom. The mud drum serves as frostproofing for the tank and column supply lines. This type has been made only by one manufacturer. No investigation has been made of the features which are patented, as the cost shows the type to be in open competition with other storage tanks without any large addition for royalty. The manufacturer places $1,800 for 50,000-gallon tank, and $3,000 for 100,000-gallon tank as a fair price during a prosperous period, which includes substructure, steel roof and erection, but excludes foundation and freight and roof.

The Standpipe Type has been applied to railroad water stations by two large Western roads. The portion below a line about 12 ft. above the rail acts as a settling basin for water carrying sediment, which can be readily washed out. One of the roads uses this type as a combined storage tank and water softener, the raw water and chemicals being introduced at the bottom, the treated water being drawn from the upper portion by means of a floating intake. The plans of the two roads differ mainly in the foundation, one consisting of reinforced concrete, the other of an excavation filled with broken stone or gravel. Your Committee regrets it was unable to analyze the designs and submit at this time a recommended plan, but as the type is considered of great merit, plans of each are submitted in Appendix L with the following brief statement of costs:

REINFORCED CONCRETE FOUNDATION.					BROKEN STONE OR GRAVEL FOUNDATION.		
Height.	Dia.	Foundation.	Tank.	Total.	Height.	Dia.	Cost.
31′-5″	24′	$586	$1987	$2573	28′-2″	24′	$2000
		869	1987	2856	42′-4″	24′	2500
62′-3″	24′	586	4228	4814			
		869	4228	5097	59′-7″	24′	3000

The two costs of concrete foundation are for warm and cold climates. The tanks on concrete foundations are heavier than the others approximately as follows: 31-ft. tank, 1,500 lbs.; 47-ft. tank, 5,000 lbs., and 62-ft. tank, 8,000 lbs., which would account for part of the difference in cost as follows, based on steel in place at 6 cents a lb.: 31-ft. tank, $90; 47-ft. tank, $300; 62-ft. tank, $480. With steel tanks provision for increased storage can be made by using heavier material in the part first erected, additional height being provided at relatively small cost whenever necessary. In view of this advantage over wood, the greater life, larger scrap value, the small increase in

cost and the conclusions reached earlier under discussion of Tub—kind of material, your Committee anticipate the general adoption of steel in the near future and recommend same as good practice.

COSTS.

The costs of Storage Tanks vary as do other railroad structures with the fluctuation of prices of material and labor, and this, together with different physical conditions and freight charges, makes an exact comparison of actual costs impossible for lack of sufficient details, but the costs as given in Appendix J, obtained from 12 railroads, is offered as representing the best data available in addition to that hereinbefore given. It appears that a 50,000-gallon tub on timber substructure and concrete foundation costs somewhere about $1,800. The cost of same on steel substructure varies largely with the design of substructure, but $1,800 is offered as an approximate figure of the recommended plan.

TUB UNIT CAPACITY.

The prevailing size of tub is 16 ft. high by 24 ft. in diameter, commonly called a 50,000-gallon tub. In recent years tubs 20 ft. by 30 ft. in diameter, designated as 100,000-gallon tubs, have been erected to some extent. Where additional storage is required same is secured by a battery of tubs of those sizes, this being due to the limit placed by difficulty in securing larger timber. The use of steel water tanks removes the limit placed on the size of wood, and as their use is growing the sizes of the units will be determined by the relation of consumption, cost of installation and cost of operation. Ordinarily it is cheaper between terminals to provide storage capacity to carry over night than to use a night pumper. This requires consideration of probable increase above the maximum consumption within the life of the tub. It is believed that the consumption will in most cases at least double in 20 years, and therefore the unit would be at least 50 per cent. greater than the maximum daily consumption, which will avoid a night pumper for a considerable period without undue expense of installation, which could be offset when installed by the pumper operating two or more stations.

The capacity of tubs at terminals also depends on the relation of consumption, cost of installation and operation. However, the consumption is usually large compared with outlying stations, and the pumping can frequently be done day and night with steam or electricity from a power plant with the necessary attention by the engineer or fireman, in which event the tub merely acts as an equalizer to take care of heavy and light periods during the 24 hours, and no conclusion can be offered regarding relation between consumption and tub units at terminals except that the tub unit capacity at terminals depends upon local conditions and is usually less than the consumption.

DELIVERY LINES FROM TUBS.

TANK SPOUT AND COLUMN SUPPLY LINE.

Earlier in this report reference was made to the location of storage (a) near the track reducing the cost of delivery line and (b) distant from track at increased cost of delivery line. The main advantage of the former is the smaller cost of delivery line, consisting of Tank Spout and Fixtures. Water Columns are more liable to be damaged when being turned to and from the tender, since this is not always done with the locomotive at rest. In other respects there are many disadvantages to Tank Spouts outlined in the Water Service Committee report to the 1901 convention as follows:

"The height must be approximately uniform, whereas greater height than this arrangement permits is often desirable, for better head, giving quicker service, for fire protection, etc.; position of tank is restricted, whereas choice of location is often desirable for various reasons, viz., more favorable ground, better view around curves or from highway crossings, less liability to injury from a collision, defective equipment and fire; much greater difficulty to protect from frost; spouts not being properly put up out of the way and hanging low enough to strike men on top of cars, many accidents of the kind having occurred; waste water when spout is put up causing slop in summer and ice in winter."

In the same report the cost of 10-in. water column with 100 ft. of 10-in. pipe line between it and the bottom of tub, with masonry pit, drainage and frost box under tub on 20-ft. posts, is said to add about $700 to the cost of low tub and spout. The above is endorsed subject to the objection to elevating the tub hereinbefore outlined. Further objection to tank spout is found in the location of a permanent structure where it may require removal or will limit future track development and because ordinarily water can be delivered to but one track.

The following conclusion is offered:

When the cost is not of first importance, or when the objections to tank spout are not nullified by local conditions in special cases, the use of water columns instead of tank spouts is recommended as good practice.

Detail consideration of tank spout and fixtures is left for the future.

COLUMN SUPPLY LINE.

Your Committee have not made tests to determine the losses in column supply line, but present the following discussion of same from data in its possession: A 12-in. Water Column and 14-in. supply line delivered 5,000 gallons per minute under a head of 20 ft. above the column nozzle; the pressure head in the 14-in. main just before entering column was 12.25 ft. above the same datum.

The head lost at entrance to 14-in. pipe at bottom of tub is $m\frac{v_1}{2g}$

in which "m" is a coefficient depending on the form of the pipe at entrance and will here be considered the same as a standard tube, viz., 0.5. The head lost in friction in supply line is $f\frac{l}{d}\frac{v_2}{2g}$, in which "$f$" is the friction factor of pipe, "l" the length in feet, and "d" the diameter in feet. (The value of "f," used hereafter, was obtained from chapter on "Flow Through Pipes" in Merriman's Hydraulics.)

The head lost in the Water Column and valve is $n\frac{v^2}{2g}$, in which "n" is the unknown friction factor.

The hydrostatic head "H," which is 20 ft., equals the sum of the lost heads plus the velocity and pressure heads of the issuing stream, hence $H = m\frac{v^2}{2g} + f\frac{l}{d}\frac{v^2}{2g} + n\frac{V^2}{2g} + \frac{V^2}{2g} + h$, in which the last two members are the velocity and pressure heads of the issuing stream. "f" $=$ .017, "l" $= 230$, v and V are obtained from the discharge and the sizes of the pipe and Water Column, and "h," the pressure head of the issuing stream, is zero. Substituting and solving for the friction factor of the column and valve we find $n = 3.63$, and restoring all the quantities the total head is found to be expended as follows:

.8 ft. lost at entrance.
5.3 ft. lost in friction between column and tank.
10.9 ft. lost in column valve and column.
3.0 ft. effective velocity head of issuing stream.

20

The value of the formula in this connection consists in showing where the losses occur, but it can be used in the design of a layout by adding another member to the equation to cover the head lost in elbows (values of which your Committee understands have recently been published by the American Society of Civil Engineers), provided the manufacturers would sell their water columns with guaranteed friction factors for various velocities. The question of head lost in elbows did not arise in the above case, since the observed pressure head in the supply line near the column took care of all the head lost between it and the tank; the length "l" used above, not being contained in the data, was calculated from the observed pressure head as though there were no elbows in the pipe.

The deductions from the above data are given with a certain amount of reservation, since the observations were not taken by your Committee, but they confirm opinions regarding the location of the greatest loss in head, suggest the value of tests to determine the matter and indicate that an increase in the discharge from a tank might be obtained through improved design in the column valve rather than by increasing the size of the supply line.

WATER COLUMNS.

The following are the general features to be borne in mind in the design of a water column and supply line.

The supply line should be the same size as column where storage tank and column are not over 100 ft. distant; where of greater distance, the supply line should be one size larger. There should be as few bends as possible and all should be long radius. This supply pipe should be provided with gate valves at tank and at water column.

The column pit should be of masonry and as near waterproof as possible, and provided with drainage. Good substantial foundation of masonry for the column should be provided.

The column valve should be designed so as to give as little friction as possible. It should operate easily and from the *top of the pipe* so that it can only be opened from the locomotive tender. It should be provided with by-passes so as to be cushioned automatically by water pressure in opening and closing. An extra automatic device should be provided on pipes located in cold climates so as to drain the column above the valve. This should be so arranged that it can be cut out during the warm months.

The turning device should be so arranged that the pipe can be turned from the tender or from the ground, and so that the pipe will be automatically locked in a position with the horizontal pipe parallel to the track. This lock should be positive so as not to be easily tampered with.

The horizontal pipe, when flexible joints are used, should have a vertical movement to accommodate different tender heights.

All moving portions should be easily accessible. The valve should be so arranged that the seats can be readily and quickly gotten at for repairs.

(6) TYPICAL INSTALLATIONS.

The matter of typical installations for different conditions is one that, owing to a lack of time for its proper consideration, the Committee wishes to carry over for another year and asks that it be reassigned.

(7) METHODS OF OPERATION.

In regard to the general operation of steam or gasoline pumping plants the Committee recommends that it is much more economical, from a maintenance standpoint, to hire regular pumpers to do the pumping at both steam and gasoline plants rather than depend upon some other employé. This pumper can be assigned to other duties which will not interfere with his duties as pumper. These pumpers can be moved from place to place, covering two or three plants, and sometimes more, if the plants are properly designed. They will keep the plants in better order with less repair cost than if the plant is run by some other employé not fitted for the work. Where conditions do not warrant a

pumper, the engineer of some neighboring industry can sometimes be utilized as a pumper at a very reasonable figure.

The Committee recommends that accurate record be kept of the cost of pumping water per effective horsepower and comparisons be made of the different plants. This record should be kept by the use of a pressure gage on discharge pipe and revolution counter on pump. The pump should be carefully calibrated every thirty days so that a definite ratio can be established between counter and water discharged. This record will frequently develop some weak spot in the plant on which a few dollars spent would mean a large saving in operation.

Appendix C gives "Pumping Report" recommended.

Appendix D gives "Monthly Record of Cost of Water Supply."

Appendix E gives "Water Station Record." In using this it is designed to have one page for each water station and have the sheets bound in loose leaf so that additions as made can be added after a page is full.

DESIGN OF TRACK PAN.

The Committee has received copies of six different standards for track pans. The plans are all very elaborate and the Committee has not been able to go into them as thoroughly as would be required to formulate a design. The plans have been analyzed and compared, however, with the following results:

LOCATION.

All are located on tangent as shown by plans. Track pans have, however, been installed on curves up to 2 degrees.

FOUNDATION.

All are fastened to track ties from 8 in. x 9 in., 8 ft., to 8 in. x 10 in., 8 ft. 6 in., and a 2-in. dap in tie is generally made to bring top of pan level with top of rail.

LENGTH.

Varies from 1,200 to 1,800 ft.

CROSS-SECTION.

Widths are 4-19 in., 1-25 in. and 1-23⅝ in. in clear at top. Depths 6 in. to 7 in.; 4 have straight sides and 2 have return lips made of channels or angles. The 19-in. section seems to give the best results so far as the Committee has been able to determine.

END INCLINES.

These vary as follows. The portion beyond the pan extends from 4 ft. to 6 ft. and the portion in the pan from 6 ft. to 10 ft. In part of the plans the rate of incline is different, depending on whether it is an entrance or exit.

WATER CONNECTIONS.

In all cases they enter in bottom of pan. Size from 4 in. to 6 in. Expansion and contraction taken care of in 5 cases by rubber hose and in one by a packed joint. Various styles of inlets: 1 has 2 holes 4 x 3/4 in. x 3½ in., with a deflector directly over inlet; 1 has an enlarged pipe from 6 in. to 11 in., with no deflector; 1 has a large box arranged with a deflector at top; 2 have a large number of ½-in. to 3/4-in. holes in bottom plate; 1 plan had no detail of inlet on it.

HEATING DEVICE.

All are heated by steam. Two do not show details; 1 uses the injector principle and heats water by jet of steam before it enters pans; 3 admit steam through ⅛-in. to ¼-in. nozzles pointed downward at sides of pan every 30 or 40 ft.

This report on track pans is submitted as a progress report, and the Committee asks that the subject be reassigned for the next year.

CONCLUSIONS.

Your Committee desires to submit the following conclusions in regard to the general principles of water supply:

Supply, Quantity.—If possible within economical limits, supply should be obtained sufficiently large so that the total amount of water likely to be required during the average volume of business in 24 hours can be drawn from the source in 7 hours at terminal stations and in 4 hours at intermediate stations.

Supply, Source.—Where water of suitable quality, and in sufficient quantity, can be purchased at a reasonable figure, it is recommended above all other sources.

Springs should be carefully gaged for a period of at least one year and the possibility of future pollution and increased demands for supply therefrom carefully considered before their adoption as a permanent source. Reservoir should be constructed at spring where conditions will permit.

Lakes, natural ponds, creeks or rivers require special investigation in each case. Points to be considered are quantity, quality as regards chemical impurities and amount of sediment carried, future pollution and riparian rights. Style of intake will depend on local conditions entirely. No definite rules can be given.

Dug well construction should always be preceded by a careful auger test to determine strata to be encountered. Size and construction depend on strata to be passed through, and no definite rule can be given.

Surface pipe wells are very satisfactory where local conditions permit of their use. The system is one which can be extended to collect a large volume of ground waters.

Artesian deep wells, where obtainable, are a very satisfactory source. Their flow is liable to constantly decrease and finally stop altogether.

Deep wells requiring pumping are only recommended as a last resort.

A chemical analysis of all waters should be made and the question of cost of treatment if required thoroughly investigated, as previously outlined in the Manual.

PUMPING PLANTS.—Size of plant should be in accordance with table following:

Quantity Per 24 Hrs., in Gallons.	TERMINAL STATIONS. Time Pump to Run in 24 Hrs.	TERMINAL STATIONS. Gallons Per Minute.	INTERMEDIATE STATIONS. Time Pump to Run in 24 Hrs.	INTERMEDIATE STATIONS. Gallons Per Minute
2,000,000	20 Hours.....	1666	20 Hours.....	1666
1,750,000	20 Hours.....	1458	20 Hours.....	1458
1,500,000	20 Hours.....	1250	20 Hours.....	1250
1,250,000	20 Hours.....	1042	20 Hours.....	1042
1,000,000	20 Hours.....	833	20 Hours.....	833
900,000	20 Hours.....	733	20 Hours.....	733
800,000	20 Hours.....	666	20 Hours.....	666
700,000	20 Hours.....	583	20 Hours.....	583
600,000	20 Hours.....	500	10 Hours.....	1000
500,000	7 Hours.....	1189	10 Hours.....	833
450,000	7 Hours.....	1071	10 Hours.....	750
4000,00	7 Hours.....	928	10 Hours.....	666
350,000	7 Hours.....	838	10 Hours.....	583
300,000	7 Hours.....	714	10 Hours.....	500
250,000	7 Hours.....	595	4 Hours.....	1041
200,000	7 Hours.....	476	4 Hours.....	833
150,000	7 Hours.....	357	4 Hours.....	625
100,000	7 Hours.....	238	4 Hours.....	416
50,000	7 Hours.....	119	4 Hours.....	208
25,000	7 Hours.....	60	4 Hours.....	104

Size of discharge pipe should be decided in accordance with the following:
Use 4″ Cast Iron Pipe where Qd x H is most nearly equal to 0.355.
Use 6″ Cast Iron Pipe where Qd x H is most nearly equal to 0.437.
Use 8″ Cast Iron Pipe where Qd x H is most nearly equal to 0.519.
Use 10″ Cast Iron Pipe where Qd x H is most nearly equal to 0.656.
Use 12″ Cast Iron Pipe where Qd x H is most nearly equal to 0.820.
Use 14″ Cast Iron Pipe where Qd x H is most nearly equal to 1.162.

When Qd=Average quantity of water pumped per 24 hours in 1,000 gallons and H= friction head in feet for one foot of pipe for quantity of water plant is to handle per minute.

Static head should be obtained. Friction head should be calculated in accordance with friction tables and 50 per cent. added thereto for the aging of the piping system.

The effective horsepower will be

$$\frac{\text{Gallons per minute} \times \text{static head} + \text{friction head in feet.}}{{}^{*}4{,}000}$$

Steam should be selected for power for plants up to 5 E. H.P. when most of the following conditions obtain:

*Amend to read "3960" instead of "4,000."

(A) Where one hundred pounds of coal unloaded into a pumphouse is cheaper than one gallon of gasoline delivered at gasoline storage tank, taking into consideration the number of hours the plant is to be operated and the location of plant as regards delivery of fuel; special attention also being paid to the proper design of pump as regards size of steam and water cylinders on large plants.

(B) Where a steam plant is maintained for other purposes, as at terminals where shops are run by steam.

(C) Where interest charge on plant is less than it would be on a gasoline plant.

Gasoline should be selected as a motive power where most of the following conditions obtain:

(A) Where one gallon of gasoline delivered at gasoline storage tank is cheaper than 100 lbs. of coal unloaded into the pumphouse, special consideration being given to locations remote from trackage and isolated stations where train service is such that pumper can, by pumping the whole of his time between trains, do the pumping at two or three stations.

(B) Where the quality of the water is such that it will necessitate heavy boiler repairs, provided boiler compounds cannot be successfully used.

(C) Where interest charge on plant is less than it would be on steam plant.

Boiler selected should have the relation to E. H.P., as shown by Appendix I, and should carry 100 lbs. steam.

Steam pump selected should have the ratio of water to steam cylinders as large as possible. Water cylinder should be of proper size to discharge the required amount of water per minute, assuming 70 strokes per minute for each cylinder. Pump efficiency should be assumed as 66 2-3 per cent. Initial steam pressure, 90 lbs. per square in. Proper ratio of water to steam cylinder should be as per diagram 4. Size of steam cylinder should be in accordance with this size of water cylinder and ratio (see diagram 3, Appendix H).

Gasoline engine selected should have a commercial brake horsepower rating of twice the effective horsepower. Engine and gearing for reduction of speed should be all on one base, with friction clutch connection to pump shaft.

Power pump, where suction lift is such that the pump can be on same level as engine, may be of the triple single-acting type, or duplex double-acting, direct connected to engine friction clutch. For small plants the combined engine and pump are recommended.

Power pump, where suction lift is such that the pump must be at a lower level than engine, should be single cylinder, double-acting type, connected to engine by means of a pitman face plate and shaft.

Number of strokes per minute, pitman and stroke length should be as follows:

12 in. Stroke, Pitman length 6 ft., No. Strokes per minute 70.
18 in. Stroke, Pitman length 6 ft., No. Strokes per minute 46.
24 in. Stroke, Pitman length 8 ft., No. Strokes per minute 35.
30 in. Stroke, Pitman length 10 ft., No. Strokes per minute 28.
36 in. Stroke, Pitman length 12 ft., No. Strokes per minute 23.

Deep well pumping plants, where gasoline driven, should have same proportion of stroke pitman, and number of strokes per minute as above. When steam driven, the proportions should be as follows:
Stroke 12 in., No. Strokes per minute 60, No. Cylinder discharges 30.
Stroke 18 in., No. Strokes per minute 40, No. Cylinder discharges 20.
Stroke 24 in., No. Strokes per minute 30, No. Cylinder discharges 15.
Stroke 30 in., No. Strokes per minute 24, No. Cylinder discharges 12.
Stroke 36 in., No. Strokes per minute 20, No. Cylinder discharges 10.

Size of gasoline engine and steam head should be in same ratio as for surface pumps.

*Pumphouses should be of non-combustible material. In gasoline plants engine should be in a room by itself, with floor vents. Stoves should not be permitted in gasoline engine rooms. Where there are deep wells, the house should be so designed that it can be removed or opened to admit of a well machine being placed over it. At terminal stations the pumphouse should be incorporated with other part of plant where possible.

Each plant should be fitted with a pressure gage on discharge pipe and a revolution counter on pump.

METHODS OF DELIVERY TO LOCOMOTIVES.

FUNCTION OF WATER STATION.

(1) A water station, as an elementary proposition, consists of a supply of water, with means of delivering same to locomotive. This is done by gravity, except with Track Pans, where the same elementary arrangement is present, with an added principle for completing the delivery in those special cases.

Where the topography will permit full elevation the arrangement may consist of an elevated reservoir, excavated in the ground, with pipe line and water column.

Where only partial elevation can be secured it may consist of a tub resting on the surface, with pipe line and water column.

Where the topography will not offer even partial elevation, same must be secured by artificial means, permitting of choice in location of the supply, which is done by placing same (a) near the track, reducing the cost of delivery line, and (b) distant from the track, although at increased cost of delivery line.

The prevailing topography makes artificial elevation necessary at

*Amend by inserting the words "and lights" after the word "stoves."

a large majority of water stations, resulting in the structure known as a Storage Tank, which is subdivided, naturally, into its structural elements, on the same lines as those occasioned by varying topographical conditions, viz., Foundation, Substructure, Tub and Delivery Line.

STORAGE TANKS.

(1) The foundation should be made of any good masonry locally available, provided it also withstands the disintegrating action of water.

It should be carried below frost line and as much deeper as necessary to reach firm bearing, unless piles or other sub-foundations are used.

(2) For substructure and joists the use of steel is recommended. Increasing the height of the substructure increases the discharge by less than the ratio between the square roots of the two heads. Increasing the size of the column supply line increases the discharge by more than the ratio between the squares of the two radii. The work of pumping hence fuel consumption is directly proportional to the head pumped against.

Twelve-inch columns are practicable and in most cases sufficient with tub 15 to 20 ft. above the rail, which is recommended as the most economical height.

In special cases it may be more economical to use substructures higher than 15 to 20 ft. on account of the length of column supply line or because the source of supply is elevated, particularly when from a municipal plant.

(3) Tub.—The life of white pine tubs used in the past does not exceed twenty years, the quality used at present is inferior and will have a life of less than twenty years, the price has been increasing rapidly, even with the use of interior lumber. The life of cypress used in the past does not exceed twenty-five years, the quality at present is as good as in the past, the price has been rapidly increasing. Further increase in the price of wood tubs is to be expected in view of the rapid depletion of forests. The use of wood in tubs limits the capacity of same.

Details.

SPECIFICATIONS FOR 50,000-GALLON WHITE PINE TUBS.

(1) (a) The inside diameters shall be 24 ft. at the bottom and 23 ft. at the top. The staves shall be 16 ft. long. The tub shall be made of carefully selected white pine lumber, surfaced to 2¾ in., which is free from sap, shakes, unsound knots, or other imperfections which can cause leaks or will impair the durability of the tub. (All small black knots extending entirely through the plank shall be carefully bored and thoroughly plugged.*) All staves shall be full length without splicing. Every joint shall be machine-made and perfect,

*When cypress is used, omit the sentence about small black knots.

and the stave joints sawed on true radial lines, with due regard to top and bottom diameter of tub.

(b) The crozing at bottom of staves shall be cut with proper regard for pitch of stave when in position, and circular in shape, so as to be completely filled by tub bottom when staves are driven up.

(c) The outside of staves shall be surfaced convex so as to give a full bearing to hoop throughout the width of each stave.

(d) The tub shall be provided with hoops, as shown on plan, with single bolt pressed steel draw lugs and bolts for tightening.

(e) One extra stave and dowel pins shall be furnished with each tub. Every tub shall be set up at the factory and the bottom and corresponding stave marked and numbered before being knocked down for shipment. The location of the hoops shall also be marked on the staves.

(f) Hoops shall be of muck bar iron, 4 in. wide by 5-16 in. thick, spaced as shown on plan, furnished in three sections and equipped with one-bolt pressed steel lugs and bolts.

(2) Roof may be of material and design to conform with available markets and other structures.

(3) Wooden Storage Tanks.—The plan submitted in Appendix K is recommended as good practice.

STEEL STORAGE TANKS

Steel tanks are recommended as good practice unless the character of water prevents their use. They have a life more than double that of wood and larger scrap value when dismantled; the first cost is not much greater than wood, while the cost for proper maintenance of either is about the same. Provision for increased storage can be made with steel tanks when first erected, the additional capacity to be obtained by making tank higher whenever necessary at small cost compared with that of an additional wooden tank. Further merit of steel tanks is reflected in conclusion under Tub—kind of material, stated earlier. The Hemispherical Bottom Steel Tank with steel substructure is not used ordinarily except at terminals. Three types of steel tanks are used at intermediate water stations, viz., Flat-Bottom Tub on steel substructure, Hemiellipsoidal Bottom Tub, supported by steel posts around the outside, and a cylinder or mud-drum 5 or 6 ft. in diameter at the center of the bottom, the mud-drum serving as frost-proofing for the tank and column supply lines, and as a settling basin for sediment which is washed out through blow-off valve.

Standpipe Tub, consisting of a tub imposed directly on the foundation, the substructure being omitted. The portion below the water column nozzle acts as a settling basin for sediment, which can be readily washed out. This type may be used as a combined storage tank and water softener, the raw water and chemicals being introduced at the bottom, the treated water being drawn from upper portion by means of a floating intake.

TUB UNIT CAPACITY.

(1) The tub unit capacity at Intermediate Water Stations depends on the relation of consumption, cost of installation and operation. It is recommended that the unit be at least 50 per cent. greater than the maximum daily consumption when erected.

(2) The tub unit capacity at terminals also depends on the relation of consumption, cost of installation and operation. The unit capacity in this case is particularly subject to local conditions and no general relation obtains between it and the consumption. Ordinarily the tub serves as an equalizer to take care of heavy and light periods during the 24 hours, and the unit is generally less than the consumption.

WATER COLUMNS.

When the cost is not of first importance, or when the objections to tank spouts are not nullified by local conditions in special cases, the use of water columns is recommended as good practice.

Supply line should be same size as column where distance to storage tank is not over 100 ft.; where distance is greater, one size larger is recommended.

Column pit should be waterproof and drained.

Column valve should operate from locomotive tender only, and should be water-cushioned and provided with automatic drain for part of column above freezing line in cold climates.

Turning device should operate from tender or ground and have automatic lock to keep horizontal part of column parallel to track.

Horizontal pipe, when flexible joints are used, should have vertical movement sufficient to accommodate high and low engine tenders.

All moving parts of column for operating same should be easy of access.

OPERATION.

Regular employes should be kept in the service whose principal business is the operation of the pumping plant. A traveling repairman should visit each plant periodically and attend to all repairs, which cannot be made when plant is running.

Accurate records should be at hand in the office of the official having charge of this branch of the service, as indicated by Appendix E.

Accurate reports of pumping service should be kept, as indicated in Appendices C and D.

Respectfully submitted,

C. L. Ransom, Resident Engineer, Chicago & Northwestern Railway, Omaha, Neb., *Chairman.*

M. H. Wickhorst, Engineer of Tests, Chicago, Burlington & Quincy Railroad, Aurora, Ill., *Vice-Chairman.*

J. L. Campbell, Engineer Maintenance of Way, El Paso & Southwestern Railway System, El Paso, Tex.

RECOMMENDED PLAN OF 50,000 GALLON WOODEN STORAGE TANK.

J. P. Congdon, Supervising Engineer, Oregon Short Line, Pocatello, Ida.

Robert Ferriday, Engineer Maintenance of Way, Cleveland, Cincinnati, Chicago & St. Louis Railway, Indianapolis, Ind.

G. H. Herrold, Division Engineer, Chicago Great Western Railway, Chicago, Ill.

E. G. Lane, Engineer Maintenance of Way, Baltimore & Ohio Railroad, Pittsburg, Pa.

L. B. Merriam, Division Engineer, Grand Trunk Pacific Railway, Winnipeg, Man.

C. A. Morse, Chief Engineer, Atchison, Topeka & Santa Fe Railway, Topeka, Kan.

L. P. Rossiter, Division Engineer, Baltimore & Ohio Railroad, Pittsburg, Pa.

Committee.

Appendix A.

STEAM PUMPING TESTS.

No. of Test	Pump.				Boiler		Coal		Height Raised	Pipe Lines		Total Time of Test	Work Done			Coal Used		Labor
	Type.	Steam	Water	Stroke	Type	Com H.P.	Kind Size	B. T. U.		Suction	Discharge		Total Gal. Water Pumped	Gal. per Min.	E.H.P.	Total Pounds	lbs. per E.H.P. per Hr.	
1	Duplex	12 "	7½"	17 "	....	....	Bit. M. R.	14,000	35′	18′-4½″	400′-4″	8 h.	65,376	136	1.37	730	67	Total..$1.18
2	Simplex D. A.	7½″.	6 "	10 "	Vert.	15	Bit. M. R.	....	52′	95′- 6″	2400′-4″	4 h.	24,080	100	1.78	411	58	Total...0.75
3	Simplex D. A.	7½″	6 "	10 "	Vert.	14	Bit. M. R.	....	66′	810′- 6″	1030′-4″	4 h.	23,424	98	1.83	220	30	Total...0.50
4	Simplex D. A.	12 "	7 "	12 "	[illegible]cot.	30	Bit. M. R.	10,000	147′	16′- 5″	300′-4″	10 h.	30,360	50	1.89	1,275	67	Day ...1.67
5	Simplex D. A.	7½″	7½″	7 "	Vert.	25	Ant. Slac.	13,900	46′	20′- 4″	160′-3″	93 m.	13,180	142	1.93	80	27	Mo....35.00
6	Simplex D. A.	9 "	6 "	12 "	Vert.	10	Bit. M. R.	14,000	61′	12′- 4″	60′-4″	8 h.	61,432	128	2.00	697	44	Total...0.96
7	Duplex D. A.	10 " 10 "	8 " 7½″	12 " 12½″	Vert. Hor.	40 12	Ant. Slac.	13,600	46′	6″	75′-6″	17 h.	199,450	195	2.29	1,622	42	Mo....85.00
8	Simplex S. A.	8 "	5¾″	36 "	Vert.	12	Lig. M. R.	....	135′	40′- 4″	250′-6″	510 h.	3,002,000	98	3.30	110,000	65	Mo....44.25
9	Duplex D. A.	10 "	6 "	10 "	Vert.	30	Bit. M. R.	....	74′	440′- 6″	4845′-6″	4 h.	43,344	181	4.14	775	47	Total...0.75
10	Simplex S. A.	12 "	7¾″	36 "	Vert.	40	Bit. M. R.	9,675	133′	100′- 8″	125′-6″	2 h.	16,485	137	4.61	420	45	Total...0.30
11	Duplex D. A.	10 " 10 "	10½″ 10½″	12 " 12 "	Loco. Loco.	100 100	Bit. M. R.	13,600	49′	80′-12″	65′-10″	20 h.	580,000	483	6.06	4,900	40	Mo...136.00
12	Duplex D. A.	14 "	8½″	12 "	Vert.	40	Bit. M. R.	9,675	48′	30′- 8″	800′-6″	50 m.	25,900	504	8.53	125	17	Total...0.15

13	Simplex S. A.	12 "	7¾"	36 "	Vert.	40	Bit. M. R.	9,675	229'	170'- 8"	60'-6"	2 h.	18,840	157	9.09	300	16	Total. . 0.30
14	Simplex Duplex D. A.	12 " 12 "	10 " 10 "	14 " 12 "	Loco.	60	Lig. M. R.	....	206'	26'- 4"	6824'-6"	825 h.	9,823,960	200	11.80	482,000	49	Mo. . . . 50.00
15	Duplex D. A.	17 "	12 "	15 "	Loco.	....	Pea	13,500	101'	160' 10"	2742'-8"	16 h.	500,000	528	15.67	5,600	22	Day . . . 2.13
16	Duplex D. A.	14 "	10 "	15 "	Loco.	60	Bit. M. R.	11,190	64'	19'- 8"	3650'-8"	8 h.	366,944	764	21.14	4,552	27	Total. . . 1.04
17	Duplex D. A.	14 "	8½"	12 "	Loco.	....	Bit. M. R.	....	249'	9'- 6"	8000'-6"	20 h.	232,775	194	11.62	5,665	25	Total. 80.00

AVERAGE 1 E. H.P. TO 5 E. H.P. PLANTS, 49.7 LBS. COAL PER E. H.P. HR.

Appendix A.

GASOLINE PUMPING TESTS.

No. of Test	Engine		Pump			Height Raised	Pipe Lines		Total Time of Test	Work Done			Gasoline		Labor
	Size H. P.	Type	Type	Diam. Cyl.	Stroke		Suction	Discharge		Total Gal. Water Pumped	Gal. per Min.	Eff. H. P.	Total Gal.	Gal. per E.H.P. per Hr.	
1	5	Hor. and Jack	Sgl. D. A.	6 "	18″	60′	20′- 5″	50′-4″	165 h.	342,000	34	0.51	55	0.64	Mo. . $11.00
2	10	Hor. and Jack	Sgl. D. A.	6 "	18″	60′	30′- 5″	106′-4″	197 h.	602,000	51	0.76	92	0.52	Mo. . . .15.00
3	5	Hor. and Jack	Sgl. D. A.	5 "	12″	60′	50′- 4″	1720′-3″	312 h.	945,000	50	0.92	190	0.66	Mo. . . .15.00
4	5	Hor. and Jack	Sgl. Deep Well	4½″	24″	100′	20′- 5″	75′-4″	482 h.	1,173,000	40	1.00	255	0.52	Mo. . . .34.00
5	5	Hor. and Jack	Sgl. D. A.	5 "	18″	38′	10′- 4″	70′-4″	8 h.	49,022	102	1.00	5.25	0.66	Total . .1.50
6	5	Hor. and Jack	Sgl. D. A.	6 "	18″	80′	20′- 4″	700′-4″	170 h.	908,000	53	1.06	90	0.52	Mo. 7.33
7	4	Combined	. . . .	7 "	8″	37′	873′- 4″	44′-4″	104 h.	624,000	100	1.11	52	0.45	Mo. . . .10.00
8	10	. . . .	Sgl. D. A.	8 "	12″	35′	200′- 6″	100′-6″	12 h.	150,000	125	1.12	12	0.89	Day . . .1.33
9	. . . . . .	Hor. and Jack	Sgl. Deep Well	4¼″	24″	68′	8′- 3″	125′-3″	3 h.	11,688	65	1.15	2.45	0.71	Total. . .0.75
10	5	Hor. and Jack	Sgl. D. A.	4¾″	36″	100′	20′- 5″	80′-4″	25 h.	75,925	50	1.27	16	0.50	Total. . .5.00
11	5	Hor. and Jack	Sgl. D. A.	6 "	18″	65′	20′- 4″	60′-4″	5½ h.	27,120	82	1.35	6.3	0.98	Total. . .1.00
12	5	Hor. and Jack	Sgl. D. A.	6 "	18″	65′	20′- 4″	60′-4″	4 h.	20,370	85	1.42	2.8	0.48	Total. . .1.00

13	10	Hor. and Jack	Sgl. D. A.	6 "	18"	38'	14'- 4"	62'-4"	8 h.	71,040	148	1.47	6	0.51	Total..0.60
14	6	Gear Base	Sgl. Deep Well	5¾"	12"	100'	20'- 5"	50'-4"	900 h.	3,174,264	59	1.50	896	0.66	Mo....20.00
15	5	Hor. and Jack	Sgl. D. A.	6 "	18"	60'	20'- 5"	50'-4"	335 h.	362,000	108	1.62	165	0.30	Mo....22.00
16	......	Gear Base	Sgl. D. A.	8 "	12"	44'	75'- 6"	1950'-6"	7 h.	61,369	146	1.77	4.92	0.40	Mo....40.00
17	8	Gear Base	Sgl. D. A.	8½"	12"	55'	00'- 6"	150'-6"	2¼ h.	18,360	136	1.90	2.23	0.52	Mo....10.00
18	6	Gear Base	Sgl. D. A.	6 "	18"	61'	20'- 6"	200'-6"	4 h.	31,812	133	2.06	2.75	0.33	Total..0.40
19	......	....	Trip S. A.	7 "	8"	26'	623'- 4"	Wood 430'-5"	4 h.	43,344	181	2.06	4⅓	0.52	Total..0.75
20	10	Combined	....	8½"	12"	75'	00'- 6"	100'-6"	2½ h.	21,805	145	2.76	2.38	0.34	Mo....20.00
21	10	Combined	Sgl. D. A.	8½"	12"	53'	12'- 6"	150'-4"	57 m.	14,430	253	3.87	1.25	0.34	No. Chg.
22	10	Combined	....	9½"	12"	43'	20'- 7"	60'-4"	8 h.	162,750	339	4.14	8.00	0.24	Total..1.10
23	15	Combined	Sgl. D. A.	8½"	12"	56'	9'- 4" 7'- 6"	185'-5"	77 m.	24,570	319	4.55	2¼	0.36	Mo....10.00
24	20	....	Sgl. D. A.	8 "	12"	70'	40'- 6"	6000'-6"	24 h.	288,000	200	4.67	45	0.40	Day ...1.67
25	20	....	....	10½"	12"	113'	....	7000'-8"	30 h.	3,580,687	446	12.7	77.17	0.2025	....
26	......	....	Trip D. A.	8 "	12"	74'	30'-10"	775'-6"	4 h.	151,600	632	16.6	11½	0.173	Total..0.67

AVERAGE 0.5 TO 5.0 E. H.P. ENGINES, 0.514 GAL. GASOLINE PER E. H.P. HR.

COMPARATIVE STATEMENT OF REPAIRS.

Plant.		July '07	Aug. '07	Sept. '07	Oct. '07	Nov. '07	Dec. '07	Jan. '08	Feb. '08	Mar. '08	April '08	May '08	June '08	Totals	Average per Mo.
Gasoline. New Plants.	1	8.27	9.90	5.55	97.18	19.22	17.60	8.15	7.50	9.80	5.20	7.87	7.20	203.44	16.95
	2	4.67	18.00	7.40	7.04	56.40	14.95	7.00	7.50	11.02	9.88	9.91	13.00	166.77	13.89
	3	15.75		Plant	Taken	Out	of	Service.		Plant	Taken	Out	of	Service.	
	4	4.70	13.50	7.40	7.04	12.35	6.60	10.89	7.50	13.47	13.00	7.14	9.60	113.19	9.43
	5	13.50	6.75	9.25	8.80	11.47	6.60	6.69	5.00	8.57	40.00	5.10	7.20	128.93	10.74
	6	52.75	13.50	13.05	13.05	46.13	6.60	10.00	15.00	15.92	15.60	8.16	18.20	227.96	18.99
	7	7.87	9.00	7.40	7.04	14.14	2.20	6.06	3.75	7.35	15.60	4.08	7.20	91.69	7.64
	8	7.87	6.75	7.95	7.04	12.30	2.20	6.06	3.75	7.35	11.70	3.06	7.20	83.23	6.93
													Average.	145.03	12.08
Steam. Age Not Given.	9	26.25	22.60	34.22	27.15	23.18	87.76	43.56	45.00	17.15	25.70	20.45	31.20	404.22	33.68
	10	26.19	11.25	13.69	11.09	13.70	24.20	21.38	15.00	8.70	8.58	6.00	12.00	171.78	14.31
	11	13.50	11.25	6.10	9.32	10.25	8.80	7.26	5.00	9.57	10.40	6.12	7.20	104.87	8.74
	12	4.50	13.50	5.55	16.72	13.41	37.50	6.05	7.75	8.57	13.00	4.08	9.60	140.23	11.68
	13	37.75	15.75	25.71	8.80	5.50	6.60	9.68	5.00	7.35	10.40	7.14	12.00	141.68	11.81
	14	....	....	....	....	....	....	....	....	....	....	....	Average.	192.55	16.04

COMPARATIVE STATEMENT OF REPAIRS.

		1905.	1906.	1907.	Average per Year.	Average per Mo.
Gasoline. Age Not Given.	A	49.23	65.31	51.92	55.42	4.62
	B	53.80	95.48	62.43	70.57	5.88
	C	8.89	12.21	29.41	16.84	1.40
	D	74 92	21.25	39.58	45.25	3.77
	E	32.40	30.94	70.72	44.69	3.72
	F	20.50	18.09	24.25	20.95	1.74
				Average.	42.29	3.52
Steam. Age Not Given.	G	32.03	41.64	114.66	62.78	5.23
	H	26.09	37.60	71.40	45.03	3.75
				Average	53.90	4.49

Appendix B.

COMPARATIVE STATEMENT OF COST FOR WATER STATION REPAIRS ON GASOLINE AND STEAM PUMPING PLANTS.

The two statements are from different roads.

In the monthly report the size of plant was not given, except that the plants ran from 5,000 gal. to 15,000 gal. per hour. Gasoline plants were new.

In the yearly report size of plant not given.

Age of Steam Plants not given in either case.

Appendix B-1.

ACTUAL COST OF REPAIRS TO GASOLINE PUMPING PLANTS.

Costs are for total Labor and Material for Repairs only. A-Number of 1,000 gallons pumped per Month. B-Cost of repairs per month.

MONTH.	1		2		3		4		5		6		7		8		9		10		11		12		13		14	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Feb., 1907	....	....	470	....	480	....	285	....	91	....	104	....	94	$16	312	....	Plant not in operation.		19	....	....	....	380	$6	....	....	Plant not in operation.	....
March, 1907	....	....	650	....	195	....	285	....	166	....	172	....	71	....	392	....			....	....	....	$24	423	21	300	$2		....
April, 1907	....	$3	613	$5	315	$15	265	....	75	$2	214	$5	....	2	423	$3		....	....	....	....	....	373	50	195	2		....
May, 1907	440	3	618	....	405	....	305	....	172	1	243	16	....	1	613	....		....	48	....	32	....	390	....	218	....		....
June, 1907	39	....	630	....	227	....	296	3	146	5	136	32	409	28	543	5		....	....	52	205	3	455	....	237	11		....
July, 1907	66	6	775	....	371	9	505	....	198	....	121	11	520	7	387	13		....	....	30	136	....	487	....	227	....		....
August, 1907	26	4	745	....	525	3	565	2	270	6	326	....	975	....	650	3		....	81	....	65	20	553	....	150	....		....
Sept., 1907	91	5	825	....	573	12	712	....	260	1	327	....	650	5	780	15		....	65	3	33	20	520	4	156	....		....
Oct., 1907	62	....	878	....	780	6	730	9	208	3	234	....	710	....	610	3		....	....	....	....	....	257	....	166	....		....
Nov., 1907	....	2	683	....	612	15	472	....	250	8	293	3	573	6	525	....		....	....	....	....	289	....	185	....			....
Dec., 1907	94	9	733	....	733	11	528	4	256	4	148	....	458	3	474	....	39	....	182	4	71	2	298	9	162	....	48	$2
Jan., 1908	....	....	733	....	597	....	376	....	178	3	97	4	133	....	364	....	97	5	32	4	58	....	267	....	162	....	65	....
Feb., 1908	65	....	681	....	330	....	327	....	97	4	71	4	....	....	327	....	81	5	97	4	....	....	260	....	130	....	52	....
March, 1908	91	....	760	....	234	....	442	....	55	....	42	....	293	....	....	....	27	....	....	....	28	....	260	....	166	....	88	....
April, 1908	65	....	723	....	198	....	140	....	52	....	36	....	276	....	....	....	....	....	....	....	....	....	276	....	172	....	92	....
Total No. 1,000 Gallons Pumped	1039		10429		6575		6183		2474		2564		5162		6400		244		524		628		5488		2626		345	
Total Cost for repairs	$32.00		$5.00		$71.00		$18.00		$37.00		$75.00		$68.00		$42.00		$10.00		$97.00		$69.00		$90.00		$15.00		$2.00	
Size and Age of Engine	.... 5 Yr.		30 H.P. 4 Yr.		8 H.P. 2 Yr.		5 H.P. 6 Yr.		5 H.P. 6 Yr.		10 H.P. 4 Yr.		30 H.P. 4 Yr.		5 H.P. 8 Yr.		5 H.P. 11 Yr.		3½ H.P. 3 Yr.		3½ H.P. 3 Yr.		5 H.P. 6 Yr.		8 H.P. 6 Yr.		8 H.P. 1 Yr.	
Av. No. 1,000 Gallons pumped per annum	832		8363		5260		2546		1979		2027		4129		2720		585		419		502		4390		2100		829	
Av. cost per annum	$25.60		$4.00		$56.80		$14.60		$29.60		$60.00		$52.40		$33.60		$24.00		$77.60		$55.20		$72.00		$12.00		$4.80	
Av. cost per annum per 1,000 gal. pumped	.0306		.0005		.0108		.0057		.0150		.0296		.0127		.0123		.0410		.0185		.1099		.0164		.0057		.0058	

Form M. W. 1301.

Appendix C.—DAILY PUMPER'S REPORT.

——3 Inches—— ★ ——3 Inches——

PUMPING REPORT	Hour.	Min.	Hour.	Min.	Hour.	Min.
Time started..						
Time stopped.						
Time ran......						
Counter at start .						
Counter when stopped						
Dif'rence counter						
Gage at start....						
Gage when stopped.						
Average gage.....						

Pounds Coal used........................

Gallons Gasoline used ....

Other Fuel used.................... .....

STATION..............................

Date........ ....19....

Received To-day	SUPPLIES RECEIVED	Balance on Hand Last Day of Month
	Kinds Tons Coal	
	Gallons Gasoline	
	Quarts Gas Eng. Oil	
	Quarts Cylinder Oil	
	Quarts Car Oil	
	Quarts ....Oil	
	Pounds Waste	

(Folding Line.)

Pumper.

——5½ Inches—— REPORT SIDE

★

——5½ Inches—— ADDRESS SIDE

Size of Card 5½ x 6 inches, printed both sides.

Railway Business

ADDRESS OF OFFICIAL

(Folding Line.)

INSTRUCTIONS

Each pumper will fill out one of these reports each day for each plant worked at and forward to (Title) ....

In the supply report fill in the column headed "Balance on hand last day of month" only on the report for the last of the month, showing the supplies on hand at the close of the work on the last day of the month.

Appendix D.

Size of Blank, 8x14 in.

Form M. W. 1302

STATEMENT OF COST OF PUMPING WATER

STATION	DATE	TIME PUMP RAN		No. Rev. of Counter	Gallons Per Rev.	GALLONS PUMPED		Gage Press. in Feet	H.P. = Gal. per Min × Head Feet ÷ 4000	FUEL REPORTED AS USED			SUPPLIES RECEIVED																COST RECORD INCLUDING LABOR			
													Coal @ $		Gasoline @ $		Other Fuel		Gas Engine Oil @		Cylinder Oil @		Car Oil @		Other Oil @		Waste @					
		Hr.	Min.			Total	Per Min.			Coal Pounds	Gasoline Gallons	Other Fuel	Tons	Cost	Gal.	Cost		Cost	Qts.	Cost	Qts.	Cost	Qts.	Cost	Qts.	Cost	Lbs.	Cost	Total Lbs. & Mtl.	Per 1000 Gal.	Per Hour	Per H.P. Hour

Appendix E.

WATER STATION RECORD

AT________________________

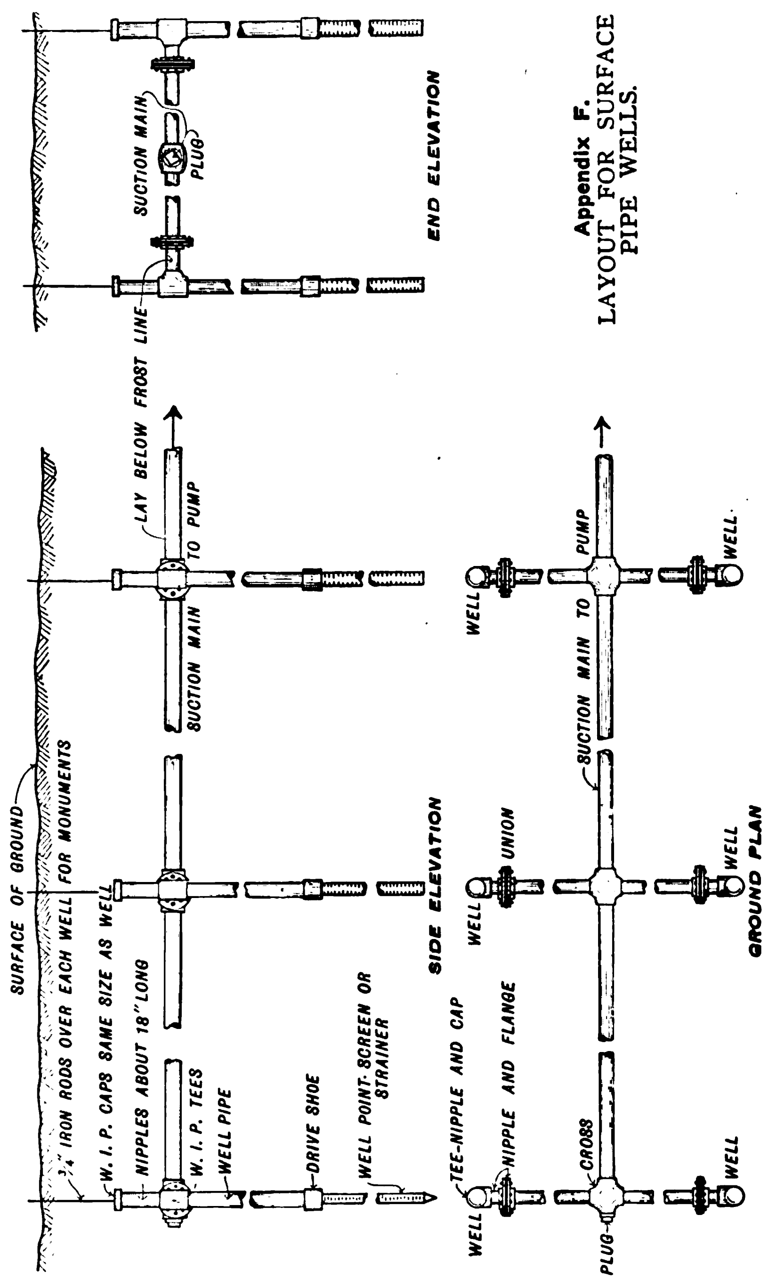
WHERE PAINTING RECORD IS DESIRED ENTER DATE PAINTED WITH PREFIX "P" IN DATE COLUMN.

WHERE SECOND-HAND EQUIPMENT IS INSTALLED ENTER DATE OF MANUFACTURE IN BRACKETS OVER INSTALLATION DATE.

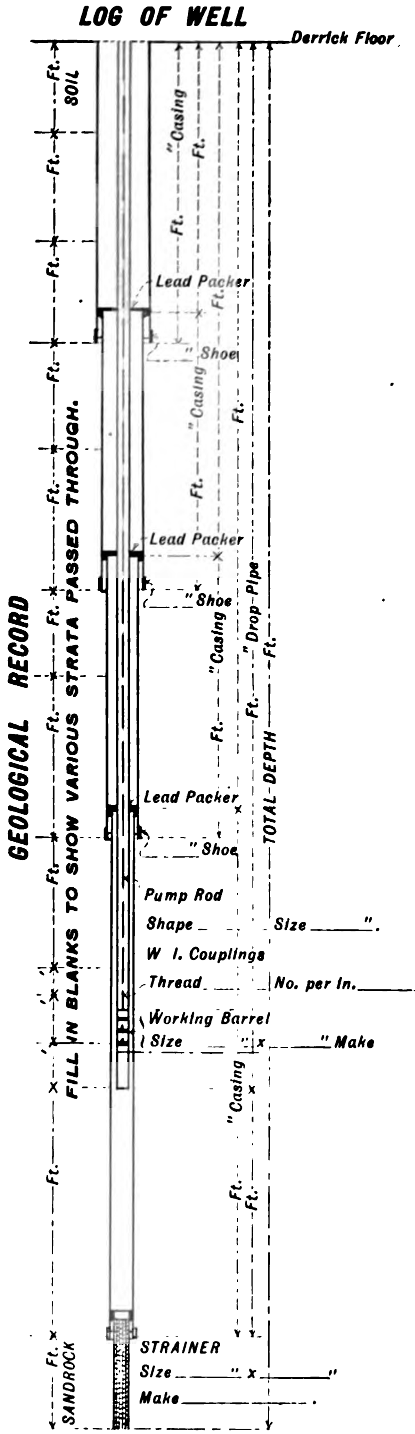
WATER TANKS, SETTLING TANKS INCLUDED								WATER COLUMN										PUMP HOUSE							PUMP PIT				WIND MILLS					
			Tub						Pit				Column																Tower			Wheel		
Date	Foundation	Substruct	Diam.	Hght.	Capacity Gallons	Frost Box	Plan Reference	Date	Width	Lght.	Depth	Matl.	Kind	Col. Diam.	Col. Supply	C. Col. Toc. Tk	Top Rail to Bot. Spout	Date	Width	Length	Sill to Plate	Foundation	Above Found.	Roof	Date	Size	Depth	Material	Date	Kind	Hght.	Date	Kind	Diam.

BOILERS														PUMPS									ENGINES					TREATING PLANTS	
	Boiler							Stack			Injector									Size									
				Shell																									
Date Installed	Shop No.	Name Maker	Kind	Lgth.	Diam.	Size Grate	No. & Size Flues	Date	Diam.	Height	Size	Kind	Date	Maker and Shop Number	Steam Power or Belt	Simple or Compound Expansion	Single or Double Action	No. of Water Cylinders	Steam	Water	Stroke	Date	Maker and Shop Number	Kind	Rated H.P.	Connections from Engine to Pump	Date	Maker and Plan Reference

WATER SUPPLY															HEIGHTS			ANALYSIS		PIPE LINES SEE ______ FOR LOCATION																						COST RECORD		
Dug Wells						Pipe Wells									Top Tank to					Steam			Exhaust			Suction			Discharge			Column Supply			Other Lines									
		Diam.						Diam.																																				
Date	Source	Top	Bottom	Total Depth	Material	Date	Number	Top	Bottom	Total Depth	Working Barrel Below Top Well	Kind Point, Screen or Strainer	Make of Packing Head		High Water	Low Water	Center Pump	Lbs. incrust. Solids per 1000 gal.	Fitness for Engine Use	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Length	Date	Size Kind	Use	Length				Date	Work Done	Original Construction Cost



Appendix F.
LAYOUT FOR SURFACE PIPE WELLS.



Appendix G.

LAYOUT FOR DEEP WELLS.

Location ....

Date began drilling ....

Well completed ....

WATER LEVELS.

Water stands at ....ft.

And pumps down to ....ft.

When delivering ....gals. per minute.

Appendix H.

RELATIVE VALUES OF COAL AND GASOLINE AS FUEL FOR RAILROAD PUMPING STATIONS.

By A. K. SHURTLEFF.

The following analysis of the relative value of coal and gasoline as fuel for pumping stations is based almost entirely from data obtained in the practical handling of ordinary railroad water stations by the class of labor usually employed to operate the same. There is no claim for scientific accuracy in the data obtained and used in making the deductions contained herein. Mean heads were used; tank measurements taken for quantities of water handled and the fuel used, based on actual amounts charged to the stations, corrected by estimating the amount on hand at the beginning and end of each month. The coal used was "run of mine," averaging about 11,000 B. T. U. per lb. The steam pumping plants consisted of either vertical or locomotive type boilers and direct double-acting pumps of either simplex or duplex patterns, with no special protection of steam connections to boiler. Gasoline plants consisted of engine with either triplex pumps or with double-acting pump connected by pitman to jack or other speed-reduction gear.

The data obtained cover a period of several months' operation at each station and were sufficiently accurate to determine the relative values of the different fuels. The deductions made are based entirely on types of plants described, which are representative of the major portion of pumping plants as established by the railroads of this country.

STEAM PLANTS.

Diagram No. 1 shows the quantity of steam used per indicated H.P.-hour in performing work in the pump cylinder. This is exclusive of steam losses from condensation, etc. The cubic feet was first calculated from the formula given on the diagram and then converted into pounds. Particular attention is called to the effect of low cylinder pressure.

With coal of 11,000 B. T. U. per lb., and with plants as described, there was obtained an average equivalent evaporation from and at 212 degrees of about 2⅓ lbs. of useful steam. Diagram No. 2 shows the pounds of coal required per effective H.P.-hour for pumps having mechanical efficiency of 0.66⅔ and 0.75. The curve is obtained by dividing the pounds equivalent evaporation from and at 212 degrees (as shown on Diagram No. 1) by 2⅓ times the pump efficiency.

The mechanical efficiency of pumps will vary greatly. In the same pump the efficiency will be less at 100 revolutions per minute than at half this speed, as it requires more power to move the pistons at the higher speed; further, the friction of the larger amount of water in the pump passages will be increased at the higher speed. A pump handling a given quantity of water against a 200-ft. head will have a much greater efficiency than if handling the same quantity of water against a 20-ft. head, as the internal friction of pump would be practically the same. Experiments have shown efficiencies varying from 0.30 at 10-ft. lift to 0.90 at 160-ft. lift. (See Kent's Pocket Book, page 608.) For purposes of comparison, 66⅔ per cent. efficiency has been used in all the diagrams and tables, this approximating the average condition at railway pumping plants.

From Diagram No. 2 it can be seen that fuel economy demands that pumps be so proportioned that the steam pressure required in the cylinders be as high as consistent with the boiler pressure that can be safely carried, or, in other words, the ratio of area of water cylinder to area of steam cylinder be as large as practicable.

Table No. 3 gives the ratios for a number of standard makes of pumps of various proportions. Pumps of ratio greater than 0.6 are seldom built for water pressures above 75 lbs., so this must be taken into consideration when designing pumping plants. Nearly all the smaller boilers are constructed to carry safely 100 pounds pressure, so that a pressure of 90 pounds in cylinder can be safely assumed where required.

The cylinder steam pressure required to operate a pump is determined by the following formula:

$$\text{Cyl. Steam Pressure} = \frac{\text{Water Pressure} \times \text{Ratio}}{\text{Efficiency}}$$

Diagram No. 4 shows steam pressure required per pound of water pressure for various cylinder ratios.

To illustrate the value of keeping ratio of cylinders as large as possible, let us assume a plant handling 360 gallons of water per minute against a 55-ft. head. Pump efficiency 0.66⅔. There would be 5 E. H.P. of work done. Assuming not over 70 strokes per minute, water cylinders of 8-in. in diameter would be about the proper size for this work, using duplex pump. The greatest ratio of this size in standard makes is 1.78, having 6-in. steam cylinders. Steam pressure required for this work from formula would be 63.6 lbs. If a pump of 14-in. steam cylinders had been installed (ratio 0.33), the steam pressure required would be only 11.8 lbs.

The coal used per hour in the first case would be 150 lbs., while in last case it would be about 287 lbs. This is not an unusual case, and many cases exist where high-pressure pumps are working against low water pressure at great waste of fuel.

GASOLINE PLANTS.

Gasoline engines are practically a constant speed motor, and within the limits of load the internal friction of the engine is practically a constant. The engines are rated at the brake horsepower they can deliver at the main shaft or pulley.

Diagram No. 5 shows the average horsepower required to overcome the internal friction of engines of various sizes. It is made from an average of a large number of tests on the floors of two of the principal factories, combined with tests of engines that have been in actual use, and represents a fair average for engines that have been kept in reasonably good condition.

Extensive experiments by the United States Department of Agriculture (see Office of Experiment Stations, Bulletin 181) show that the quantity of gasoline used is practically directly proportional to the indicated horsepower of work done.

In railroad pumping stations the average gasoline used per indicated H.P.-hour is one pint. Under intelligent supervision this has been reduced 25 per cent., but the same is also true of the steam plants under intelligent firing. In the hands of experts on the testing floor the average gasoline used per I. H.P.-hour is about two-thirds of a pint.

The great difference in quantity of gasoline is mostly due to the air mixture, although the time of ignition also materially affects the quantity. (See article by P. F. Walker on "Economy in Gasoline Engine Operation," in *Power* for September, 1908.)

Table No. 6 shows the average quantity of gasoline used in pumping plants for various sized engines under different E. H.P. loads, assuming the efficiency of the pump and speed reduction gear as 66⅔ per cent. It will be noted that the quantity of gasoline used per E. H.P.-hour decreases as the load increases.

COMPARISON OF STEAM WITH GASOLINE.

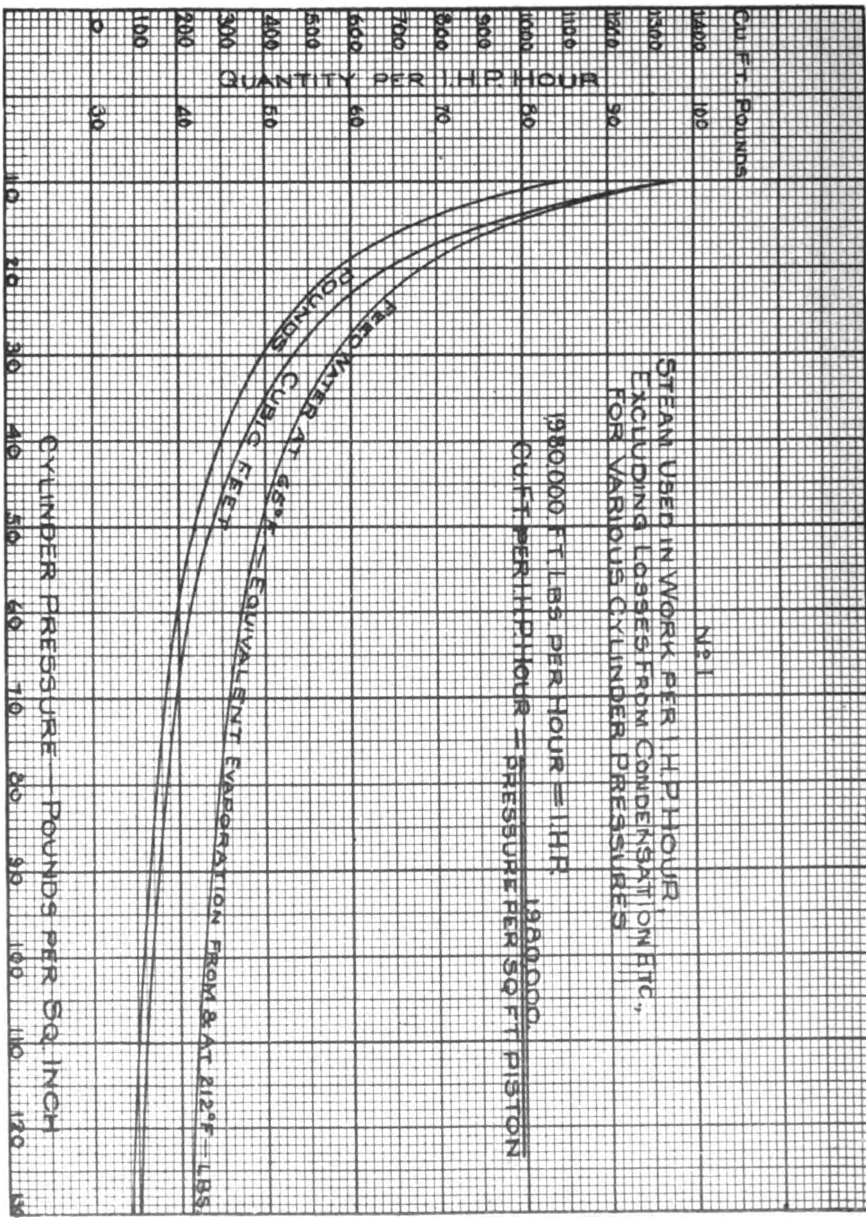
From the foregoing it can be seen that there are so many conditions entering into the quantity of fuel used that no fixed value can be made between gasoline and coal. However, the relative value can be ascertained for each particular case, and general values can be fixed within reasonable limits, providing plants are properly proportioned.

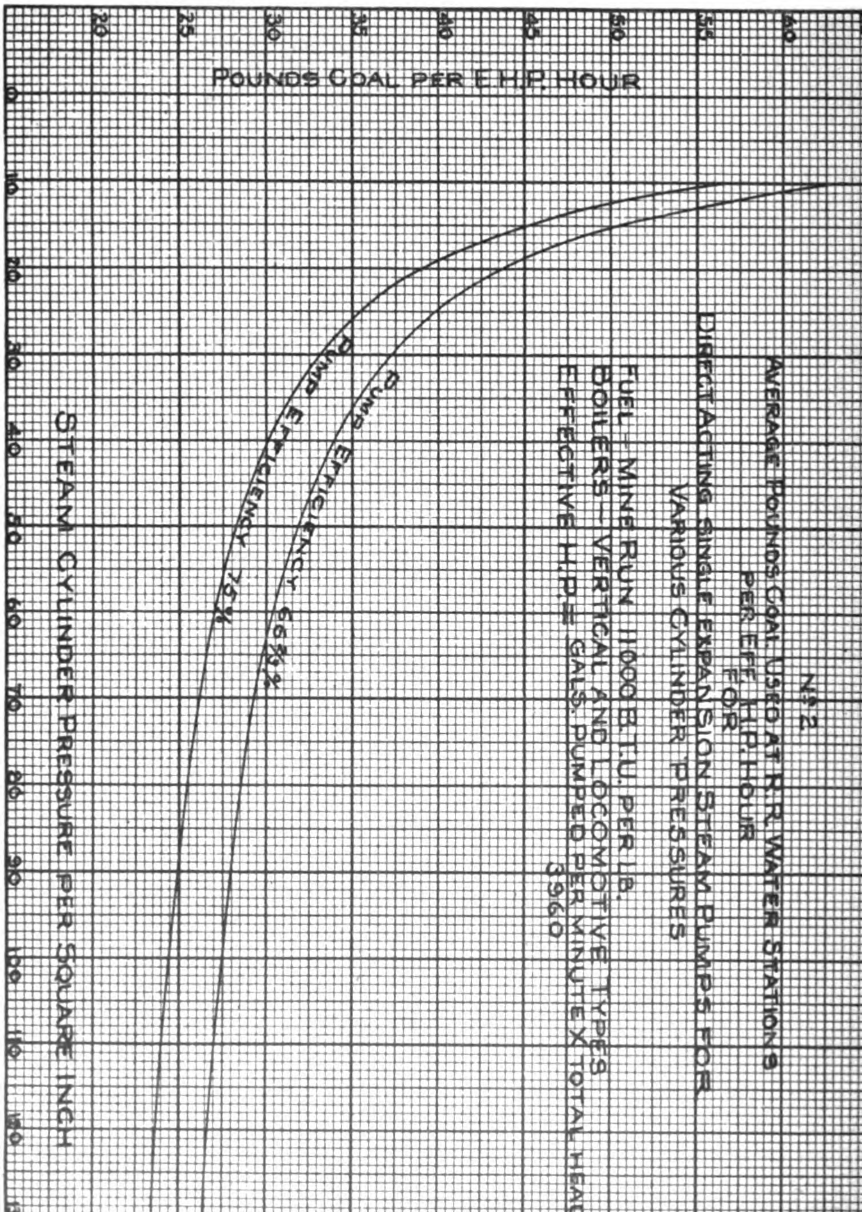
The proportioning of steam pumps should not only cover the cylinder ratios, but the water cylinder should be of a size to require not to exceed 70 strokes per minute in ordinary operation. This to give time for valves to close and reduce cost of pump repairs. In gasoline plants the engine should not be loaded above 75 per cent. of its brake horsepower. While this increases the fuel used per E. H.P.-hour, the decreased cost of repairs will more than offset the excess fuel cost.

Table No. 7 is made up on the foregoing basis from Table No. 6 and Diagram No. 2. It shows the relative value for various cylinder

steam pressures and for various sizes of engines at full load and three-fourths load.

Steam pumps are built in such various proportions that it is seldom necessary to install a pump requiring as low as 30 lbs. steam pressure. In fact, with coal of 11,000 B. T. U. per pound, and with requirements of 150 to 400 gallons water per minute, it is possible to proportion the plants with standard sizes, so that one gallon of gasoline would be equivalent to from 100 to 120 lbs. of coal, loading either type plant for economical maintenance and operation.


CU. FT. POUNDS
QUANTITY PER I.H.P. HOUR
STEAM USED IN WORK PER I.H.P. HOUR,
EXCLUDING LOSSES FROM CONDENSATION ETC.,
FOR VARIOUS CYLINDER PRESSURES
No. 1
1980000 FT. LBS PER HOUR = I.H.P.
CU. FT. PER I.H.P. HOUR = 1980000 / PRESSURE PER SQ. FT. PISTON
POUNDS
CUBIC FEET
FEED WATER AT 65° F — EQUIVALENT EVAPORATION FROM & AT 212° F — LBS.
CYLINDER PRESSURE — POUNDS PER SQ. INCH

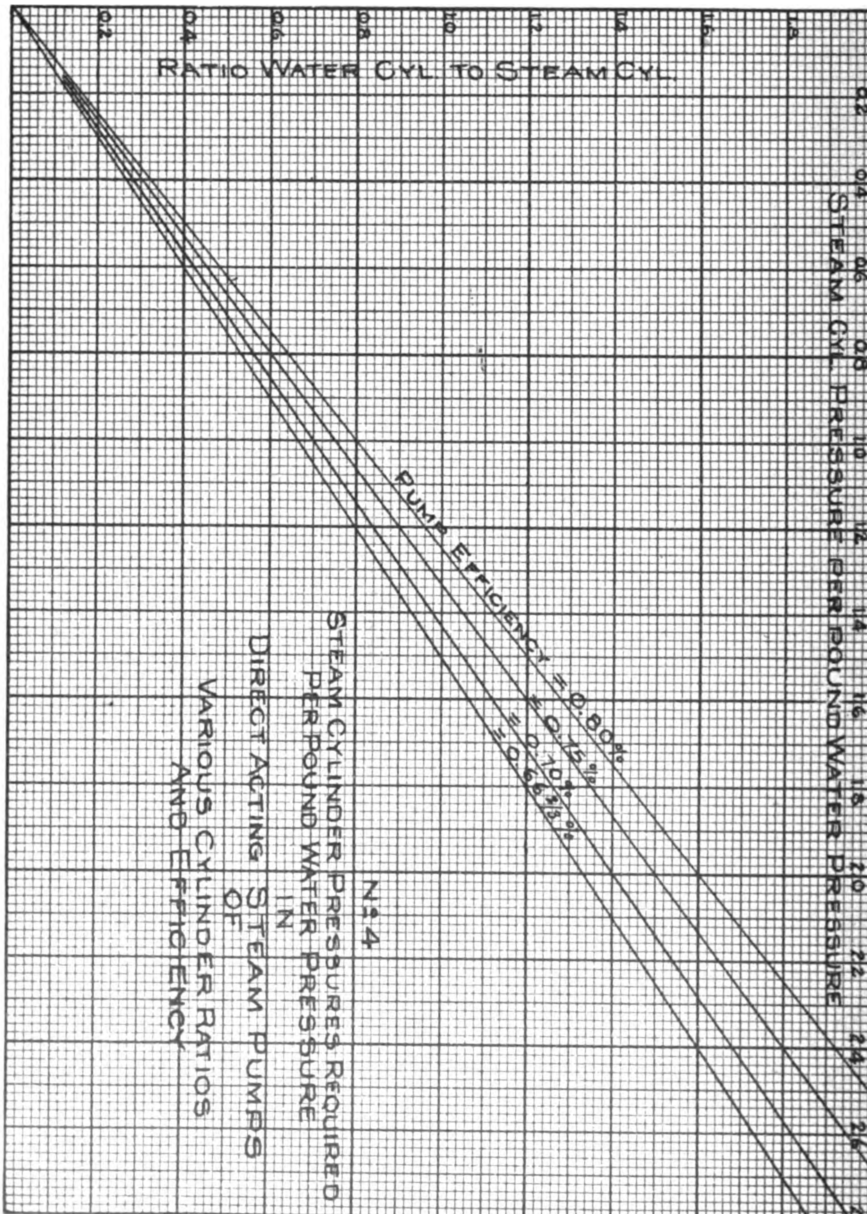

No. 2
AVERAGE POUNDS COAL USED AT R.R. WATER STATIONS
PER EFF. H.P. HOUR
FOR
DIRECT ACTING SINGLE EXPANSION STEAM PUMPS FOR
VARIOUS CYLINDER PRESSURES
FUEL—MINE RUN 1000 B.T.U. PER LB.
BOILERS—VERTICAL AND LOCOMOTIVE TYPES
EFFECTIVE H.P. = GALS. PUMPED PER MINUTE X TOTAL HEAD / 3960
POUNDS COAL PER E.H.P. HOUR
20
25
30
35
40
45
50
55
60
STEAM CYLINDER PRESSURE PER SQUARE INCH
0
10
20
30
40
50
60
70
80
90
100
110
120
130
PUMP EFFICIENCY 75%
PUMP EFFICIENCY 66⅔%

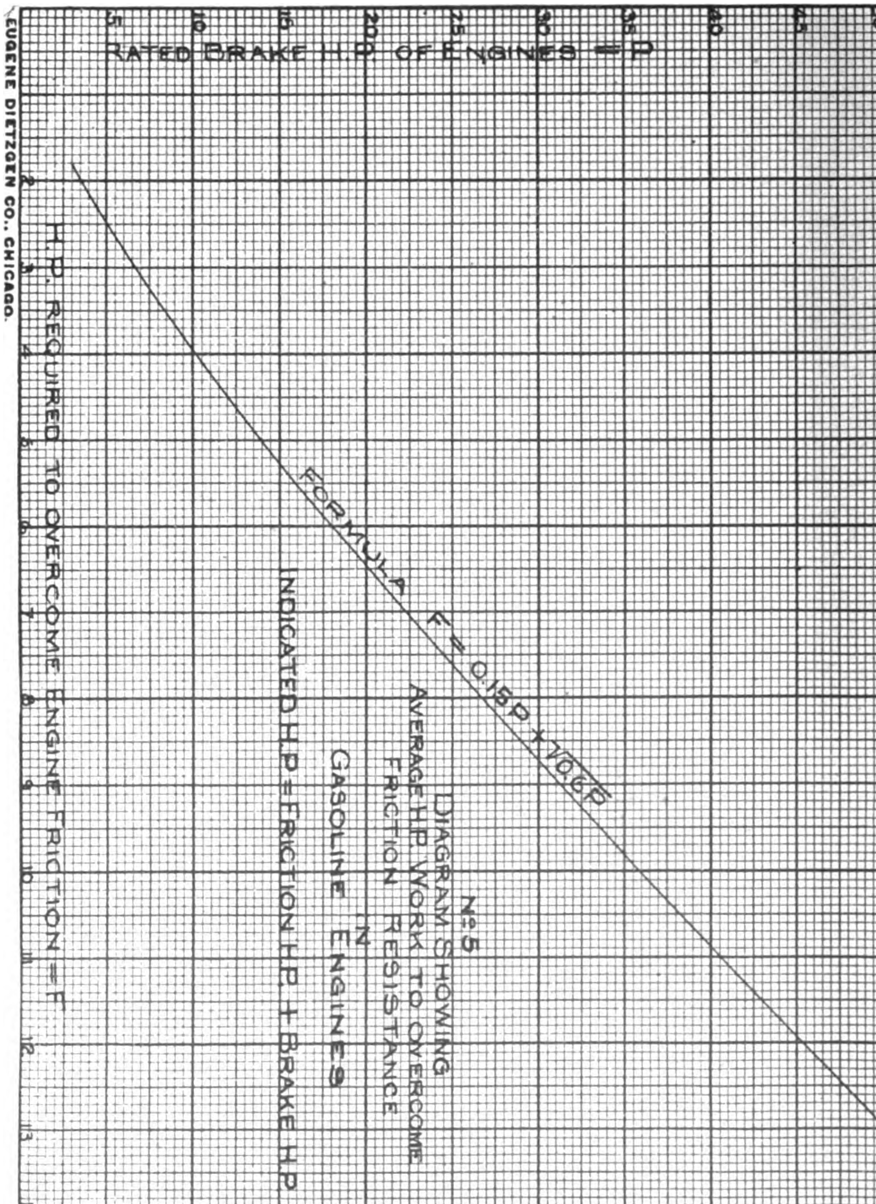
No. 3

TABLE SHOWING RATIO OF AREA OF WATER CYLINDERS TO STEAM CYLINDERS FOR VARIOUS STANDARD SIZES DIRECT ACTING STEAM PUMPS

$$\text{RATIO} = \frac{\text{AREA OF WATER CYLINDER}}{\text{AREA OF STEAM CYLINDER}}$$

DIAM. CYLINDERS		RATIO	DIAM. CYLINDERS		RATIO	DIAM. CYLINDERS		RATIO
STEAM	WATER		STEAM	WATER		STEAM	WATER	
6	5	0.69	6	7½	1.56	7	10	2.04
7	5	0.51	7½	7½	1.00	8	10	1.56
7½	5	0.44	8	7½	0.88	10	10	1.00
8	5	0.39	12	7½	0.39	12	10	0.69
9	5	0.31	14	7½	0.29	14	10	0.51
10	5	0.25	16	7½	0.22	16	10	0.39
						17	10	0.35
5	5½	1.21	6	8	1.78	18	10	0.31
5½	5½	1.00	8	8	1.00	20	10	0.25
6	5½	0.84	10	8	0.64	22	10	0.21
10	5½	0.30	12	8	0.44			
12	5½	0.21	14	8	0.33	7½	10¼	1.87
			16	8	0.25	9	10¼	1.30
5¼	5¾	1.20				10	10¼	1.05
6	5¾	0.92	6	8½	2.01	12	10¼	0.73
7½	5¾	0.59	7	8½	1.48	14	10¼	0.54
			7½	8½	1.28	16	10¼	0.41
6	6	1.00	8	8½	1.13	17	10¼	0.36
7	6	0.73	9	8½	0.89	18½	10¼	0.31
7½	6	0.64	10	8½	0.72	20	10¼	0.26
8	6	0.56	12	8½	0.50			
9	6	0.44	14	8½	0.37	17	11	0.42
10	6	0.36	16	8½	0.28	20	11	0.30
12	6	0.25	17	8½	0.25			
			18	8½	0.22	8	12	2.25
5¼	6¾	1.65	18½	8½	0.21	9	12	1.78
7	6¾	0.93				10	12	1.44
			14	9	0.41	12	12	1.00
6	7	1.36	16	9	0.32	14	12	0.73
7	7	1.00	18	9	0.25	16	12	0.56
7½	7	0.87	20	9	0.20	17	12	0.50
8	7	0.77				18	12	0.44
10	7	0.49	12	9¼	0.59	18½	12	0.42
12	7	0.34	14	9¼	0.44	20	12	0.36
14	7	0.25	16	9¼	0.33	22	12	0.30
			18½	9¼	0.25	24	12	0.25
			20	9¼	0.21	26	12	0.21


RATIO WATER CYL. TO STEAM CYL.
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
STEAM CYL. PRESSURE PER POUND WATER PRESSURE
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
PUMP EFFICIENCY = 0.80%
= 0.75%
= 0.70%
= 0.66 2/3 %
No 4
STEAM CYLINDER PRESSURES REQUIRED
PER POUND WATER PRESSURE
IN
DIRECT ACTING STEAM PUMPS
OF
VARIOUS CYLINDER RATIOS
AND EFFICIENCY



RATED BRAKE H.P. OF ENGINES = P
5
10
15
20
25
30
35
40
45
50
H.P. REQUIRED TO OVERCOME ENGINE FRICTION = F
2
3
4
5
6
7
8
9
10
11
12
13
14
FORMULA F = 0.15P + √0.6P
No. 5
DIAGRAM SHOWING
AVERAGE H.P. WORK TO OVERCOME
FRICTION RESISTANCE
IN
GASOLINE ENGINES
INDICATED H.P. = FRICTION H.P. + BRAKE H.P.
EUGENE DIETZGEN CO., CHICAGO.

1	1.81	1.81	1.55	1.55	1.42	1.42	1.28	1.28	1.14	1.14	1.00	1.00	0.84	0.84	0.75	0.75	0.68	0.68	0.61	0.61	0.54	0.54	0.50	0.50
2	2.00	1.00	1.74	0.87	1.60	0.80	1.47	0.74	1.33	0.67	1.18	0.59	1.03	0.62	0.94	0.47	0.87	0.44	0.80	0.40	0.73	0.37	0.69	0.35
3	2.19	0.73	1.93	0.64	1.79	0.60	1.66	0.55	1.52	0.51	1.37	0.46	1.22	0.41	1.12	0.37	1.06	0.35	0.99	0.33	0.91	0.30	0.87	0.29
4	2.37	0.59	2.11	0.53	1.98	0.50	1.84	0.46	1.70	0.43	1.56	0.39	1.41	0.35	1.31	0.33	1.24	0.31	1.17	0.29	1.10	0.28		
5	2.56	0.51	2.30	0.46	2.17	0.43	2.03	0.41	1.89	0.38	1.75	0.35	1.59	0.32	1.50	0.30	1.43	0.29	1.36	0.27				
6	2.75	.46	2.49	.42	2.35	.39	2.22	.37	2.08	.35	1.93	.32	1.78	.30	1.69	.28	1.62	.27						
7	2.94	.42	2.68	.38	2.54	.36	2.41	.34	2.27	.32	2.12	.30	1.97	.28	1.88	.27								
8	3.12	.39	2.86	.36	2.73	.34	2.59	.32	2.45	.31	2.31	.29	2.16	.27	2.06	.26								
9	3.31	.37	3.05	.34	2.92	.32	2.78	.31	2.64	.29	2.50	.28	2.34	.26										
10	3.50	0.35	3.24	0.32	3.10	0.31	2.97	0.30	2.83	0.28	2.68	0.27	2.53	0.25										
11	3.69	.34	3.43	.31	3.29	.30	3.16	.29	3.02	.27	2.86	.26												
12	3.87	.32	3.61	.30	3.48	.29	3.34	.28	3.20	.27	3.06	.26												
13	4.06	.31	3.80	.29	3.67	.28	3.53	.28	3.39	.26	3.25	.25												
14	4.25	.30	3.99	.28	3.85	.28	3.72	.27	3.58	.26														
15	4.44	0.30	4.18	0.28	4.04	0.27	3.91	0.26	3.77	0.25														
16	4.62	.29	4.36	.27	4.23	.26	4.09	.26	3.95	.25														
17	4.81	.28	4.55	.27	4.42	.26	4.28	.25																
18	5.00	.28	4.74	.26	4.60	.26	4.47	.25																
19	5.19	.27	4.93	.26	4.79	.25	4.66	.25																
20	5.37	0.27	5.11	0.26	4.98	0.25	4.84	0.24																
21	5.56	.27	5.30	.25	5.17	.25																		
22	5.75	.26	5.49	.25	5.35	.24																		
23	5.94	.26	5.68	.25	5.54	.24																		
24	6.12	.26	5.86	.24																				
25	6.31	0.25	6.05	0.24																				
26	6.50	.25	6.24	.24																				
27	6.69	.25																						
28	6.87	.25																						
29	7.06	.24																						
30	7.25	0.24																						
31	7.44	.24																						
32	7.62	.24																						
33	7.81	.24																						

Nº 6
GASOLINE PUMPING STATIONS

Average quantity gasoline used per hour in actual practice for various sized engines under different loads

Based on average use of one pint gasoline per Indicated H.P. Hour.

Pump Efficiency 66⅔%

E.H.P. Work done covers total lift of water including friction head

I.H.P. Work done by Engine $= 0.15\,B + \sqrt{0.6\,B} + 1.5\,E$

B = Rated Brake H.P. of Engine

E = Effective H.P. work lifting water

On testing floor in hands of experts the gasoline used averages about ⅔ of quantity shown in table

At a few water stations under intelligent supervision the above quantities have been reduced 25%

No. 7

TABLE SHOWING RELATIVE VALUE OF COAL AND GASOLINE AT PUMPING PLANTS

STEAM PLANTS HAVING VERTICAL OR LOCOMOTIVE TYPE BOILERS WITH DIRECT DOUBLE ACTING PUMPS
PUMP EFFICIENCY 66 2/3 %

B.H.P. GASOLINE ENG.	FULL LOAD E.H.P. WORK	3/4 LOAD E.H.P. WORK	30#	32#	34#	36#	38#	40#	45#	50#	55#	60#	65#	70#	75#	80#	90#
			STEAM CYLINDER PRESSURE USED AT STEAM PUMPING PLANTS — POUNDS OF COAL AVERAGING 11000 B.T.U. EQUIVALENT TO ONE GALLON OF GASOLINE														
5		$2\frac{1}{2}$	122.4	119.9	117.4	115.3	113.4	111.5	107.9	104.6	102.1	100.0	98.1	96.8	95.4	94.3	92.4
5	$3\frac{1}{3}$		133.4	130.6	127.9	125.6	123.5	121.5	117.5	114.0	111.3	109.0	106.9	105.5	103.9	102.7	100.7
6		3	122.7	120.2	117.7	115.6	113.7	111.8	108.2	104.9	102.4	100.3	98.4	97.1	95.6	94.5	92.6
6	4		135.3	132.5	129.8	127.4	125.3	123.2	119.2	115.7	112.9	110.5	108.5	107.1	105.5	104.2	102.2
8		4	127.2	124.6	122.0	119.8	117.8	115.9	112.1	108.8	106.2	103.9	102.0	100.6	99.1	98.0	96.1
8	$5\frac{1}{3}$		139.8	137.0	134.0	131.6	129.4	127.3	123.2	119.5	116.6	114.2	112.1	110.6	108.9	107.6	105.5
10		5	130.1	127.4	124.8	122.5	120.5	118.5	114.7	111.2	108.6	106.3	104.3	102.9	101.4	100.2	98.3
10	$6\frac{2}{3}$		142.6	139.7	136.7	134.3	132.0	129.8	125.6	121.9	119.0	116.5	114.2	112.8	111.1	109.8	107.7
12		6	132.1	129.4	126.7	124.4	122.3	120.3	116.4	112.9	110.2	107.9	105.9	104.5	103.0	101.7	99.8
12	8		144.5	141.5	138.6	136.1	133.8	131.6	127.3	123.5	120.6	118.1	115.8	114.3	112.6	111.3	109.1
15		$7\frac{1}{2}$	135.5	132.7	129.9	127.6	125.4	123.4	119.4	115.8	113.0	110.7	108.6	107.2	105.6	104.3	102.3
15	10		147.1	144.1	141.1	138.5	136.2	134.0	129.2	125.7	122.7	120.2	117.9	116.4	114.7	113.4	111.1
20		10	138.8	136.0	133.2	130.8	128.6	126.5	122.4	118.7	115.8	113.4	111.3	109.9	108.2	106.9	104.9
20	$13\frac{1}{3}$		149.9	146.8	143.8	141.1	138.8	136.5	132.1	128.1	126.1	122.5	120.2	118.6	116.8	115.5	113.2
25		$12\frac{1}{2}$	140.9	138.1	135.2	132.7	131.5	128.4	124.2	120.5	117.6	115.2	113.0	111.5	109.8	108.5	106.4
25	$16\frac{2}{3}$		152.4	149.3	146.1	143.5	141.1	138.8	134.3	130.3	127.1	124.5	122.2	120.6	118.8	117.4	115.1
30		15	142.7	139.8	136.9	134.4	132.2	130.0	125.8	122.0	119.1	116.6	114.4	112.9	111.2	109.9	107.8
30	20		153.7	150.6	147.4	144.8	142.4	140.0	135.5	131.4	128.3	125.6	123.2	121.6	119.8	118.4	116.1
35		$17\frac{1}{2}$	144.4	141.4	138.5	136.0	133.7	131.5	127.2	123.4	120.5	118.0	115.7	114.2	112.5	111.2	109.0
35	$23\frac{1}{3}$		155.0	151.9	148.7	146.0	143.6	141.2	136.6	132.5	129.4	126.6	124.3	122.5	120.8	119.4	117.1
40		20	145.8	142.7	139.7	137.1	134.9	132.8	128.3	124.5	121.5	119.0	116.7	115.2	113.5	112.2	110.0
40	$26\frac{2}{3}$		156.0	152.9	149.6	146.8	144.5	142.1	137.5	133.4	130.2	127.4	125.1	123.4	121.6	120.2	117.9
50		25	147.4	144.4	141.4	138.8	136.5	134.3	129.5	126.0	123.0	120.4	118.1	116.6	114.9	113.6	111.3
50	$33\frac{1}{3}$		157.6	154.4	151.2	148.4	146.0	143.5	138.9	134.7	131.5	128.8	126.3	124.7	122.8	121.4	119.0

Appendix I.

SIZE OF VERTICAL SUBMERGED FLUE AND LOCOMOTIVE TYPE BOILERS FOR RAILROAD PUMPING PLANTS FROM 1 TO 15 E. H.P.

NOTE.—These calculations are based on Boiler Pressure 100 lbs., Pump Cylinder Pressure 90 lbs., Coal 11,000 B.T.U., Water and Coal Consumption per Appendix H, 25% Added for Contingencies, Pump Efficiency 66⅔ per cent.

E.H.P. — Gal. per min. x Head in ft. ÷ 4000	I. H.P. at 66⅔% Pump Efficiency.	Pounds water per hour @ 65° F. to Steam @ 100 lbs. to be evaporated @ 44 Pounds per I. H.P.	Sq. Ft. Heat. Surface Required for Evaporation @ 2.88 lbs. Water per hour per sq. ft. heating surface.	Boiler H.P. at 10 sq. ft. Heat. Surface per H.P. per Hour 25% added for contingencies.		Pounds of Coal of 11,000 B. T. U. burned per hour to Evaporate Water using 2.8 lbs. per E. H.P. hour.	Sq. Ft.* Grate Area Required for consumption of 13 lbs. Coal per sq. ft. per hour. (Given as most economical by Christie Tests.)	Sq. Ft. Grate Area Usually Furnished in Boilers.		Pounds of Coal of 11,000 B.T.U. burned per sq. ft. grate per hour to evaporate water in boilers as usually furnished.	
				Actual.	Nearest Commercial.			Vertical.	Loco.	Vertical.	Loco.
1	1.5	66.	23.	2.9	5.	28	2.15	1.76	Not Made	15.9	Not Made
2	3.0	132.	46.	5.7	8.	56.	4.32	3.14	Not Made	17.8	Not Made
3	4.5	198.	68	8.6	10.	84.	6.47	3.14	Not Made	26.7	Not Made
4	6.0	264.	91.	11.3	12.	112.	8.52	3.14	Not Made	35.6	Not Made
5	7.5	330	112.	13.9	15.	140.	10.80	4.90	6.3	28.6	22.2
6	9.0	396.	137.	17.2	18.	168.	12.90	4.90	6.3	34.2	26.6
7	10.5	462.	160	20.0	20.	196.	15.00	7.10	9.2	27.6	21.3
8	12.0	528.	183.	23.0	25.	224.	17.20	7.10	9.2	31.5	24.3
9	13.5	594.	207.	25.8	25.	252.	19.40	7.10	9.2	35.4	27.4
10	15.0	660	222.	27.7	30.	280.	21.60	9.6	12.2	29.2	22.6
11	16.5	726.	252.	31.5	30.	308.	23.70	9.6	12.2	32.0	25.2
12	18.0	792.	275.	34.2	35.	336.	25.80	9.6	12.2	34.8	27.5
13	19.5	858.	297.	37.5	40.	364.	27.00	9.6	12.2	37.9	29.8
14	21.0	924.	322.	40.0	40.	392.	30.00	9.6	12.2	40.8	32.1
15	22.5	980.	341.	42.5	50.	420.	32.30	12.6	16.4	33.2	25.6

Appendix J.

No.	Rated Capacity Gals.	Construction Materials.			Costs (Approx. Average)			
		Foundation	Tower.	Tank.	Foun-dation	Super-struc.	Total.	Per M.Gal.
1	10,000	Concrete	18' Timber	Wood	$ 75	$ 660	$ 735	$73.50
2	30,000	Concrete	13' Timber	Wood	120	1,150	1,270	42.33
3	32,000	Stone	18' Timber	Wood	195	1,102	1,297	40.53
4	47,000	Concrete	Timber	Wood	497	1,665	2,162	46.00
5	47,000	Concrete	Timber	Wood	248	2,008	2,256	48.00
6	47,300	Stone	18' Timber	Wood	438	1,312	1,750	37.00
7	48,600	Stone	18' Timber	Wood	400	1,204	1,604	33.00
8	48,600	Piles	18' Timber	Wood	95	1,266	1,361	28.00
9	50,000	Concrete	16' Timber	Wood	396	1,404	1,800	36.00
10	50,000	Concrete	32' Timber	Wood	420	1,680	2,100	42.00
11	50,000	Concrete	Timber	Wood	200	1,300	1,500	30.00
12	50,000	Concrete	22' Timber	Wood	196	1,204	1,400	28.00
13	50,000	Concrete	12' Timber	Wood	300	1,200	1,500	30.00
14	50,000	Concrete	17' Timber	Wood	312	1,488	1,800	36.00
15	50,000	Concrete	27' Timber	Wood	312	1,688	2,000	40.00
16	50,000	Concrete	16' Steel	Wood	255	2,095	2,350	47.00
17	50,000	Concrete	32' Steel	Wood	275	2,475	2,750	55.00
18	50.000	Concrete	Steel	Wood	424	1,704	2,128	42.56
19	47,000	Concrete	Brick	Wood	730	2,466	3,196	68.00
20	47,000	Concrete	Brick	Wood	1,952	2,466	4,418	94.00
21	50,000	Concrete	Brick	Wood	*1,300	1,200	2,500	50.00
22	100,000	Concrete	Steel	Wood	900	2,100	3,000	30.00
23	50,000	Concrete	16' Steel	Steel	255	2,295	2,550	51.00
24	50,000	Concrete	32' Steel	Steel	265	2,685	2,950	59.00
25	65,000	Concrete	Steel	Steel	308	2,238	2,546	39.17
26	†65,000	Concrete	None	Steel	†586	1,987	2,573	39.59
27	†65,000	Concrete	None	Steel	†869	1,987	2,856	43.94
28	100,000	Concrete	Steel	Steel	700	2,800	3,500	35.00
29	†165,000	Concrete	None	Steel	†586	4,228	4,814	29.18
30	†165,000	Concrete	None	Steel	†869	4,228	50,97	30.89

*No. 21—Foundation Cost includes Tower.

†Nos. 26, 27, 29 and 30; Standpipe Type Capacity above the twelve-foot line. Costs are for warm and cold climates respectively.

Appendix K.

HISTORICAL NOTES ON LOCOMOTIVE WATER SUPPLY—NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

By C. H. Rice.

In the early days of railroading the question of water supply for locomotives was not nearly so important as at the present time. The locomotive tanks held but a few barrels of water and the number of locomotives was very small. In 1840 the New York & Harlem Railroad had but seven locomotives, and until 1844 the Auburn & Rochester Railroad had but ten. Regular freight service between Rochester and Auburn was started in 1846 with one train a week each way, which amply provided for the business.

Mr. William Perry, now living at Rochester, hale and hearty in spite of his 80-odd years, began railroading as a locomotive engineer in 1840, and retired from railroad service in 1880. He was more or less familiar with the old New York Central group of roads, extending from Albany to Buffalo, the first link of which—the Mohawk & Hudson River Railroad—was opened in 1831, and the last link—the Attica & Buffalo Railroad—opened in 1842. He was especially familiar with the Auburn & Rochester Railroad, opened in 1841, but all the roads were very similar in their equipment for supplying water to locomotives. Tanks were usually round (there were probably few rectangular ones) and quite small, probably about 12 ft. in diameter by 8 ft. in height, and as traffic increased a second, or even at important points a third and fourth, tank was added. These old original tanks were gradually replaced by larger tanks, but, according to present-day practice, still quite small, having a capacity at the most of 15,000 gallons. It was quite usual to house in the tank, or tanks, and a stove on the ground floor was used to prevent freezing in winter.

Frost-proof tanks made their appearance about 1872, among the first—if not the first—being one at Front Street, Schenectady. Tanks now in use are mostly quite modern, the great majority having been built since 1900, and are of 50,000 gallons capacity. The oldest tanks in use are at Alder Creek, between Utica and Carthage, built in 1874, two tanks of 6,200 gallons each.

In early days the water supply at terminals was often quite inconvenient, according to present-day standards. The New York & Harlem Railroad built shops and an engine house at Thirty-second Street, New York, in 1846, prior to which their locomotives had run to Twenty-

Sixth Street. As to the water supply at this original terminal, little or nothing is known, but at the Thirty-second Street engine house and shops the water was stored in a round tank in the shop on the west side of the street, and the locomotives were housed on the east side of street. Locomotives had to enter the shop to take water through a leather hose. After a lengthy dispute with the city, the use of steam locomotives south of Forty-second Street was discontinued about 1860.

The engine house, which was built a few hundred feet north of Forty-second Street near Madison Avenue, was equipped with a 4-in. pipe carried on roof trusses and extended around the house so as to supply each engine track. Over each tender there was a valve and a short length of leather hose. The water supply was from a large city main in Fourth Avenue.

At Albany, water was obtained by backing off the turntable onto track in the roundhouse, alongside of which a 3-in. pipe came out of the ground. It was necessary to open a stop-cock, and water was admitted through leather hose. The supply was by gravity.

At the Front Street roundhouse, Schenectady, water was pumped through pump logs from the Mohawk River into a brick tank or standpipe built up through the house, with a capacity of about 2,000 gallons. A 3-in. cast-iron pipe, connected with this tank, stood at the entrance to the house, and all engines when they went onto the turntable for turning took water through a leather hose connecting to this 3-in. pipe.

The connection from tank to tender was originally in most cases (possibly all) a copper-riveted leather hose. By 1850 metal spouts had made their appearance, and about 1853 all tanks on the Syracuse & Auburn road were equipped with copper spouts. So far as can be ascertained, wooden spouts were never used. The use of leather hose for spouts lingered in some places to quite a late date—at the New York & Harlem engine house, north of Forty-second Street, on the site of the Grand Central Yard, until the house was abandoned upon the opening of the Grand Central Station in 1871; at Ossining until about 1880. The older parts of the Rome, Watertown & Ogdensburg were originally equipped with leather hose, which were replaced by metal spouts about 1855.

In the very beginning gravity was used for water supply to tanks where it was easily attained, Victor, between Rochester and Canandaigua, being an example of such early use. The most usual practice, however, was the use of hand-power pumps. The man who worked the pump was in most cases switch tender. As traffic increased, it became necessary for the pumper to give his whole attention to keeping the tank full, and with the gradual use of night trains the employment of two men became necessary. The use of hand power continued in a few cases to quite a late date; at Batavia and Canandaigua its use was dis-

continued about 1870; it was in use on the New York & Harlem Railroad, at Pleasantville, as late as 1886.

Near Richville, on the Potsdam & Watertown Railroad, opened 1857 (now Rome, Watertown & Ogdensburg), a man hired to work a hand pump, contrived a small homemade overshot wheel to do the work and hired himself to a section foreman as a section hand, thereby getting double pay. This was soon discovered and the ingenious pumper promptly discharged, but his overshot wheel continued in service until about 1882.

Horse-power was used for pumping in a few instances. At Cayuga, Coldwater and Batavia such power was used but a short time, and about 1845 it was replaced by either hand power or hot-air engines. At Sanborn, on the Rochester, Lockport & Niagara Falls Railroad, horse-power was used until about 1870.

Little definite information is obtainable about the old hand and horse-power pumps. They were probably commercial products of the day, and the successive consolidations of lines has made it impracticable to search old files which would probably give very little information if this were practicable.

Hot-air engines were in use at an early date, possibly before 1845; by 1850 their use was rather common. About 1868 they began to be replaced by steam engines, and they rapidly disappeared from service.

About 1868 quite a number of rotary pumps were installed. Their use continued until 1875. At Fishers, between Rochester and Canandaigua, water is now pumped by a water turbine, which has been in use since about 1875.

Hydraulic rams have been used in at least three cases; at Caledonia, between Batavia and Canandaigua, where it was discontinued about 1875, and at Cold Spring and Montrose, between New York and Albany, where they did not prove satisfactory, and were replaced by hand power about 1860.

The use of windmills for pumping has been very limited. One was erected at Spencerport about 1878, and discontinued two years later. Two, supplemented by steam power, are still in use, one at Karner, the other at Chateaugay.

Steam power has been used for pumping almost, if not quite, from the beginning. The tank in the shop built by the New York & Harlem Railroad in 1846, west of Fourth Avenue at Thirty-second Street, New York, was filled by a steam pump. On the western portion of the road some Knowles pumps, installed in 1868, were used until 1902.

The first electric pump was installed at North White Plains in 1901. It is a Deane, 15,000 gallons per hour, and takes current from the company's generators. It has proved very satisfactory. A second electric pump is now being installed at Horseshoe, on the M. & M. R. R.

The first water column on the New York Central Lines was probably one in the present Grand Central Yard, installed about 1860, supplied from city main. There was no means of draining the pipe, and in cold weather fire was frequently built about it to thaw it out. About 1872 the shops at West Albany made some water columns, and one was installed at Schenectady and one at Yosts. These columns were much like those now in use, except for size. In the western part of the state columns from West Albany were first used about 1876. On the Rome, Watertown & Ogdensburg, where very severe winter weather is encountered, a short length of steam hose has been provided at each water column since 1900; steam from a locomotive blown into a column quickly relieves any trouble from frost. At other points on the system a steam jet is introduced into the pit with satisfactory results, and at yet others, a large tin lamp, with a deflector to keep water from dripping on the flame, is placed in pit in extreme weather. This latter method has proved quite effective, and it is usually made the duty of the section foreman to look after the matter.

The first track pan in the United States was built at Montrose, between New York and Albany, and put in service in 1870. It was for the use of the fast Saratoga trains at that time, was supplied with water by a hand pump, and no provision was made against cold weather, its use being discontinued in the winter.

The first track pan on the Mohawk Division was at Palatine Bridge, and was installed about 1889. It has since been replaced by one at Yosts.

The first track pan on the Western Division was built in 1892, at Churchville.

The use of pump logs was quite usual in the early days, especially on the Rome, Watertown & Ogdensburg, where the last of them was dispensed with in 1900, at Lyons Falls. At Attica and East Bloomfield, on the Western Division, pump logs were in use until 1890, when they were replaced with cast-iron pipe.

The accompanying map gives location of present water stations, and the tables give in considerable detail information concerning them.

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—MAIN LINE, WESTERN DIVISION.

No.	Station	Location	Water Supply						Tank or Reservoir					Pipe						House		
			Source	Owner	Cost	Quality	Daily Capy.	Daily Cons.	Size	Gals. Capy.	Height above R.R.	Year Built	Trough	Supply to tank Size	Supply to tank Length	Supply to tank Year laid	Tank to Column Size	Tank to Column Length	Tank to Column Year laid	Size	Kind	Year Built
YY-17	Depew	At Track	Water Works	B. & L.E. W. Co.		Good	Unlimit	130,000	Four 16x24	4 50000	4 45'	1891	None	8"	482'	1901	10"	480	1901			
"	"	At Track	"	"		"	"	"			"	"	"				8	400	1894			
YY-19	E. Buffalo E. Buffalo	Harlem Ave. N.C. Yard	" "	" City	.02 Per 1000 gal.	" "	" "	130000 17200	one 16x24	50000	20	1906	"	6	180	1903	8 6	375 5000	1903 1892			
"	"	At Eng. Ho	"	"	"	"	"	46,460	Two 16x24	2 50000	19'	1-1897 1-1903	"	6" 4"	1141 950	1899 1902	12	1400	1902	In the Eng House		
YY-20	"	At Stk Yds.	"	"	"	"	"	44428	"	"	"	1-1902 1-1897	"	4" 4"	300 325 753	1862	8	130		35x40 Frame		
YY-19	"	At Car Shops	"	"	"	"	"										6	500	1900			
YY-21	Buffalo	Seneca St.	"	"	"	"	"	43164	16x24	50000	19'	1907	"	6"	100	1897	8	210	1897			
YY-22	"	Exchange St Pass. Sta.	"	"	"	"	"	20,000									6	75	1907			
YY-23	"	Ohio St	"	"	"	"	"	33000									4	100	1900			
YY-1	"	Georgia St	"	"	"	"	"	101,129	16x24	50000	19'	1892		6"	500	1888	10	125	1900			
WN-2	B. Rock	Amherst St.	"	"	"	"	"	45000	"	50000	20	1906		6"	300	1906	12	375	1906			
WN-3	N. Tonawanda	At Track	"	"	$800.00	"	"	40000	"	50000	21'	1895		4	175	1895	12	420	1900			
WN-4	Gratwick	"	"	"		"	"		12x14	15000	20'	1901		3	100	1901	12	40	1901			
WF-8	N. Falls	At Eng. Ho	"	"	$900.00	9.00	"	190000	16x24	50000	19'	1897	"	3	75	1897	8	437	1899			
WF-7	Susp. Br.	E. End of Yard	"	"		9.10	"	65000	Three 16x24	"	20'	1905	"	6	2360	1905	12	1200	1905			
"	"	At L.V.R.R. Jct.	"	"		9.10	"	65000	One 16x24	"	16'	1903	"	4	200	1893	12 8	170 75	1901 1893			
WF-6	Sanborn	At Pass Sta	Wells	N.Y.C.		21.93	100,000	10500	"	"	19'	1894	"	4	80	1894	8	100	1894	16x24	Frame	
WF-5	Lockport	"	Water Works	City	$.06 Per 1000 gal.	17.72	Unlimit	30000	"	"	20'	1903	"	2	275	1903	12	275	1903			
WF-4	Gasport	At Track	Creek	State		Good	"	23500	12x20	30,000	20'	1903	"	4	350	1903	12	450	1903	12x16	Frame	
WF-3	Medina	At Pass Sta	Water Works	City	.06 Per 1000 gal.	26.60	"	56,000	16x24	50,000	20'	1902	"	4	35	1902	12	576	1902			
WF-2	Albion Fancher	¼ Mile West " "	M.C. Cargo Lake	" State		17.26	" "	30,000 56,000	16x24	50,000	16'6"	1900	"	3	4650	1873	12	60	1900			
"	"	"	"	"	"	"	"													12x16	Frame	

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—MAIN LINE, WESTERN DIVISION.

Pump House & Equipment																Columns							Remarks
Pump									Boiler														
Kind	Size	Gals. Per Hr.	Height Lift	Height Dis.	[illegible]	Size [illegible]	Date [illegible]	Date [illegible]	No.	Kind	Size	Steam Cap.	Date Made	Date [illegible]	[illegible]	No.	Kind	Size	Length of Arm	Height above Rail	Date Made	Date Set	
																1	Sheffield	10"	7'-8"	11'-0"	1901		
																1	Dodge	8	"	"			
																1 1	Sheffield S.Vale	10 7	7'-8" "	11'-0" "	1905 1902		
[illegible]	-38 10 [illegible]	35000 30000 60,000	7	33½		6"		1897 1901 1903	383 386 435	[illegible]	[illegible]	100 100 100		1906 1903		6	Sheffield	10	"	"	1902		New 8" pipe line—Depew & L. Erie Co.—6170 ft.
1-Knowles 1-Dodge	10"	30,000 200,000	12'	16		6" 4"			92	"	[illegible]	100		1903		1	Dodge	8	"	10'-10"	1882		
																1	S.Vale	6"	"	"	1900		
																1	Smith Vale	7"	"	11'-12"	1908		
																1	S.Vale	7"	"	"	1901		
																1	"	"	"	10'-6"	"		
																2	Sheffield	10"	"	"	1900		
																2	"	"	"	"	1906		
																2	"	"	"	"	1900		
																1	"	"	"	"	1901		
																1	Dodge	8"	"	"	1893		
																4 1	Sheffield "	10" "	" "	" "	1905 1901		
																1	Dodge	8"	"	"	1893		
1-Knowles	#6	5000	10'	16'		2"		1897	56	N.Y.C. Mor.	12 H.P.	80		1897		1	"	"	"	"	1897		
																2	Sheffield	"	"	"	1903		
1-Knowles	#7	9000	16'	30'		6"		18[illegible]	41	N.Y.C. Mor.	12 H.P.					1	"	"	"	"	1903		
																2	"	"	"	"	1902		
																1 1 1	S.Vale [illegible] Sheffield	" 8 10	" " "	" " "	1908 1900 1900		At Albion one Smith Vale Col.
1-Knowles	#7	9000	10'	30'		4"		1897	87	"	"	"		1897									

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—WESTERN DIVISION.

No.	Station	Location	Water Supply						Tank or Reservoir					Pipe						House		
			Source	Owner	Cost	Quality	Daily Capy	Daily Cons.	Size	Capy. Gals.	Height above B of R.	Year Built	Trough	Supply to Tank			Tank to Column			Size	Kind	Year Built
														Size	Length	Year laid	Size	Length	Year laid			
WF-1	Brockport	Pass. Sta.	W. Works	City	6¢ per 1000	13.76	100,000	28000	16x24	50,000	21'	1896	None	2"	100'	1896	12"	320	1903			
WA-8	Fishers	"	Creek	State		45.60	"	10000	12'x20'	30000	16'	1903	"	4"	300'	1903	12"	40	1903	12'x12'	Stone	
WA-7	Victor	"	Reservoir	F. S. Norton	30.00	18.54	90,000	16000	"	"	11'6"	1896	"	4"	400'	1861						
WA-6	Canandaigua	"	W. Works	City		6.65	Unl't'd	34000	"	"	19'	1904	"	4"	40'	1899	6"	653	1889			
"	"	In Yard	"	"			"	30000	"								6"	180'	"			
WA-5	Phelps	At Track	Springs	N.Y.C.		13.76	100,000	6500	"	30000	11'	1903	"	3"	3200'	1863	12"	80'	1903			
WA-4	Geneva	Pass Sta	Canal	State		9.56	Unl't'd	161000	16x24	50000	20'	1899	"	6"	75'		12"	505'	1906	16'x34'	Frame	1899
WA-3	Cayuga	"	Cayuga Lake	"		10.38	"	38000	"	"	"	1903	"	6"	75'	1903	12"	175'	1903	Comb. House	Brick	1903
WA-2	Auburn	In Yard	W. Works	City	500.00	8.88	Unl't'd	8000														
WA-1	Skaneateles	Pass. Sta	Creek	State		17.96	"	35000	16x24	50000	20'	1900	"	6"	1350'	1900	10"	136'	1900	13x18	Brick	1900
WR-1	Holcomb	" "	Spring	"		Good	90,000	6000	12'x20'	30000	10'	1903	"	2"	2640'	1893	12"	90'	1903			
WR-2	Honeoye F's	" "	Creek	"		"	Unl't'd	13000	16'x12'	10000	11'6"	1896	"	4"	850'	1906	8"	110'	1899	14'x22'	Frame	1883
WR-3	Maxwells	At Track	Spring	L.V.R.R.	60.00	"	4000	3900	From L.V. Track													
WR-4	Falkirk	" "	Creek	State		Fair	150,000	10000	16'x24'	50000	19'	1892	"	6"	75'	1892	8"	115'	1892		"	1892
WR-5	Clarence Cr.	" "	"	"		"	100,000	10000	16'x24'	50000	19'	1897	"	4"	130'	1897	8"	70'	1897	16'x24'	"	1897
WC-1	Charlotte	" "	Genesee River	"	From R. W. + O. Tank												8"	400'				

COMOTIVE WATER STATIONS AND TRACK PANS
W YORK CENTRAL & HUDSON RIVER RAILROAD.

No.
WF-1
WA-8
WA-7
WA-6
"
WA-5
WA-4
WA-3
WA-2
WA-1
WP-1
WP-2
WP-3
WP-4
WP-5
WC-1

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—WESTERN DIVISION.

Pump House & Equipment																Columns							Remarks
Pump									Boiler												Date		
Kind	Size	Cap'y Per Hr.	Height Lift	Height Disch.	Suction Head	Size Disch.	Date Mfg.	Date Set	No.	Kind	Size	Steam Cap'y	Date Made	Date Set	[illegible]	No.	Kind	Size	Length of arm	Height above Base R.	Made	Set	
																1	Sheffield	10	3'8"	11'-0"			
Gould	5"x5"	1,500	10'	10'		3"		1900								1	"	"	"	11'-0"			
					30'	3"										1	Tank	Spout					
																1	V. Verst	8"	7'8"	11'-0"			
																1	"	"	"	"			
					25	3"		1								1	Sheffield	10"	"	"			
1 Worthington 1 Knowles	[illegible] 8	[illegible] 12000	16	30		6"		1899	613	1 [illegible] 1 Hor.	40 HP - [illegible]			1899		2	Sheffield	10"	"	"	1907		
One Fairb.	[illegible]	[illegible]	12	40		6"		1903		Gasoline	8 HP					1	Sheffield	10"	"	"	1903		
																1	V. Verst	8"	"	"			
One Fairb.	8x12 [illegible]		12	30		6"		1900		Gasoline	10 HP					1	Sheffield	10"	"	"			
					23	2"		1893								1	"	"		"			
One Knowles	8	12000	12	20				1899	54	N.Y.C. Hor.	12 H.P.	80		1889			Tank	Spout					
																1	V. Verst	8"	7'8"	10'10"	1899		
"	8	12000	15	60				1892	37	N.Y.C. Hor.	12 H.P.	"		1896		1	Dodge	"	"	"	1892		
"	8	"	10	25				1900	34	N.Y.C. Hor.	12 H.P.	"		1901		1	V. Verst	"	"	"	1897		
																1	" "	"	"	"			

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—WEST SHORE, WESTERN DIVISION.

	Station	Location	Water Supply						Tank or Reservoir					Pipe						House		
			Source	Owner	Cost	Quality	Daily Capy.	Daily Cons.	Size	Capy. Gals.	Height above T. of R.	Year built	Trough	Supply to Tank Size	Lgth.	Year laid	Tank to column Size	Lgth.	Year laid	Size	Kind	Year built
1	Syracuse	Pass. Sta.	Water W.	City	3c per 1000 gal	7.46	Unl'td	235000									4"	125'	1884			
	"	Frt. House	"	"	"	"	"	"									"	30'	1883			
	"	Eng. Ho.	"	"	"	"	"	"									"	200'	"			
	Amboy	Pass. Sta.	Creek	State		1866 18.66	665,280	69300	Two 16x24	Two 50000	26'	1895 & 1901	None	6"	1550'	1883	8"	300'	1883	24x30	Frame	1883
	Jordan Pt. Byron	Track Track	Oswasco Outlet	"		14.86	"	54000	1-16x16 1-16x24	Temporary 60000	"	1903	drop spout	8"	550	1888	12"	350'	1906	16x18	"	1888
	Clyde	Pass. Sta.	Clyde River	"		30.32	"	55000	one 16x24	50000	20'	1902	"	8"	700'	1883	12"	650	1907	16x18	"	1883
	Newark	" "	Creek	"		42.80	"	150000	one 16x24	50,000	20'	1903	"	6"	1740	1883	12"	750	1908	16x27	"	1883
	"	Eng. House	"	"		"	"	"	one 12x14	15,000	23'	"	"	"	650	1903	8"	75'	1903			
6	Palmyra	Pass. Sta.	Mud Creek	"		23.00	"	22000	16x24	50,000	36'	1904	"	8"	800	1883	12"	600	1908	18x26	"	1907
7	Fairport	At Track	R.B.L.O.Co.	"		Good	Unlimited	42000	one 16x24	"	26'	1906	"	6"	60'	1906	12"	300	1908	18x27	"	1882
8	Genesee Jct.	"	Genesee River	"		Fair	40,000	26,500	"	"	20'	1900	"	"	150'	1900	12"	100	1908	12x16 13x18	Frame Brick	1908 1900
9	Churchville	"	Snyder Spring	NYCRR		Good	300,000	19,000	Two 16x24	Two 50,000	"	1907 1901	"	8"	6100'	1901	12"	1055	1908	21x49	"	1901
10	Byron Center	"	Black Creek	State		19.36	665280	5500	"	"	"	1900	"	6"	500	1883	8"	100	1883	16x18	Frame	1883
11	Oakfield	Pass. Sta.	Reservoir	NYCRR		16.08	"	49,000	"	"	"	1902	"	"	700	"	"	350	"	"	"	1895
	"	" "	"	"		"	"	40,000	"	"	"		"	"	4000	"						
12	Clarence	" "	Lusks Mill Pond	"		6.07	"	18,000	"	"	"	1901	"	"	"	1892	8"	800	1892	16x18	"	1892
13	Bowmansville	At Track	Creek	State		14.92	"	2,200	"	"	"	1900	"	"	150	1883	"	100	1883	"	"	1883
14	E. Buffalo	Yard Office	Water Works	City	3c per 1000 gal	8.63	Unlmt.	60,000	"			"	"				6"	30	1893			
	"	Eng. House	"	"	"	"	"	6,000				"	"				8"	800	"			
	Buffalo	W.S. Dock	Blackwell Canal	"	"	"	"		one 12x24	15,000	10'	1903	"	6"	65'	1903				12x16	"	1903

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—WEST SHORE, WESTERN DIVISION.

Division Engineer

Pump House & Equipment									Boiler							Columns							— Remarks —
Kind	Size	Capy. per Hr.	Height Lift	Height dis.	[illegible]	[illegible]	Date Made	[illegible]	No.	Kind	Size	Steam Capy.	Date Made	[illegible]	[illegible]	No.	Kind	Size	Lift of arm	Height above Top of R.	Date Model	Date Set	
																1	[illegible]	7"	8'6"	10'10"	1884		
																1	"	"	"	"	"		
																1	"	"	"	"	"		
[illegible] / 1 Fairbanks	[illegible]	35000 / 15000	8' / 8'	[illegible] / 10		6" / 6"		1883 / 1901	[illegible]	Upright / Horiz.	12 H.P.	[illegible]		1904 / 1901		2	[illegible]	10	7'6"	"	1907		
1 Fairbanks / [illegible]	[illegible] / 35	39000 / 23000	10 / 18	60 / 60		6 / 6		1908 / [illegible]	377	Upright / [illegible]	[illegible]	"		1908 / [illegible]		2	Sheffield	10	7'-6"	"	1906		
1 Fairbanks / [illegible]	[illegible] / 25	39000 / 23000	10 / 15	60 / 100		6"		1908 / [illegible]	83	"	16 H.P.	"		1908 / 1903		2	"	"	"	"	1907		
"	35	23000	10'	20		6"		1883	475	"	16 H.P.	"		"		2	"	"	"	"	1883		
																1	[illegible]	7	"	"	1903		
"	35	23000	12'	20		6"		1883	74	"	16 H.P.	"		1900		2	Sheffield	10	"	"	1908		
"	"	"	"	60		"		1882	421	N.Y.C. [illegible]	12 H.P.	"		1901		2	"	"	"	"	1908		
[illegible] Gasoline	[illegible]	39000	10 / 24	60 / 150		"		1908								1	"	"	"		1908		
Two [illegible]	8" [illegible]	Two 25000	10'	50		Two 6"		1901	380 381	Locomotive	Two [illegible]	100		1901		2	Sheffield	10"	8'6"	"	1901		
[illegible]	35	23000	10'	50		6"		1883	82	Upright	[illegible]	60		1883		2	[illegible]	7	8'6"	"	1883		
"	"	"	10'	70		6"		[illegible]	459	N.Y.C. [illegible]	12 H.P.	"		[illegible]		"	"	"	"	"	"		
					50																		
"	35	23000	8'	250		6"		1892	80	Upright	16 H.P.	60		1892		2	"	7	8'6"	"	1892		
"	"	"	14'	50		"		[illegible]	84	Upright	16 H.P.	60		[illegible]		"	"	"	"	"	1883		
																1	"	"	"	"	1893		
																2	"	"	"	"	1883		
"														1903		1	Tank Spout				1903		Gasoline

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—WEST SHORE, WESTERN DIVISION.

No.	Station	Location	Water Supply						Tank or Reservoir					Pipe						House		
			Source	Owner	Cost	Quality	Daily Capy.	Daily Cons.	Size	Capy. Gals.	Height above T. of R.	Year built	Trough	Supply to Tank			Tank to column			Size	Kind	Year built
														Size	Lgth.	Year laid	Size	Lgth.	Year laid			
WW-1	Syracuse	Pass. Sta.	Water W.	City	3c per M	7.46	Unl'td.	235,000									4"	125'	1884			
"	"	Frt. House	"	"	"	"	"	"									"	30'	1883			
"	"	Eng. Ho.	"	"	"	"	"	"									"	200'	"			
WW-2	Amboy	Pass. Sta.	Creek	State		18.66	665,280	69,300	Two 16x24	Two 50,000	26'	1885 & 1901	None	6"	1550'	1883	8"	300'	1883	24x30	Frame	1883
WW-3	Jordan Pt. Byron	Track Track	Owasco Outlet	"		18.66 14.86	"	54,000	1-10x16 1-16x24	Temporary drop spout 60,000	"	1903	"	8"	550'	1888	12"	350'	1906	16x18	"	1888
WW-4	Clyde	Pass. Sta.	Clyde River	"		30.32	"	55,000	one 16x24	50,000	20'	1902	"	8"	700'	1883	12"	650	1907	16x18	"	1883
WW-5	Newark	" "	Creek	"		42.80	"	150,000	one 16x24	50,000	20'	1903	"	6"	1240	1883	12"	750	1908	16x27	"	1883
"	"	Eng. House	"			"	"	"	one 12x14	15,000	22'	"	"	"	650	1903	8"	75'	1903			
WW-6	Palmyra	Pass. Sta.	Mud Creek	"		23.00	"	22,000	16x24	50,000	36'	1904	"	8"	800	1883	12"	600	1908	18x26	"	1907
WW-7	Fairport	At Track	R.B.L.O. Co.	"		Good	Unlimited	42,000	one 16x24	"	26'	1906	"	6"	60'	1906	12"	300	1908	18x27	"	1882
WW-8	Genesee Jct.	"	Genesee River	"		Fair	40,000	26,500	"	"	20'	1900	"	"	150'	1900	12"	100	1908	12x16 13x18	Frame Brick	1908 1900
WW-9	Churchville	"	Synder Spring	N.Y.C.R.R.		Good	300,000	19,000	Two 16x24	Two 50,000	"	1907 1901	"	8"	6100'	1901	12"	1055	1908	21x49	"	1901
WW-10	Byron Center	"	Black Creek	State		19.36	665,280	5500	"	"	"	1900	"	6"	500	1883	8"	100	1883	16x18	Frame	1883
WW-11	Oakfield	Pass. Sta.	Reservoir	N.Y.C.R.R.		16.08	"	40,000	"	"	"	1902	"	"	700	"	"	350	"	"	"	1895
"	"	" "	"	"		"	"	40,000	"	"	"		"	"	4000	"						
WW-12	Clarence	" "	Lusks Mill Pond	"		6.07	"	18,000	"	"	"	1901	"	"	"	1892	8"	800	1892	16x18	"	1892
WW-13	Bowmansville	At Track	Creek	State		14.92	"	2,200	"	"	"	1900	"	"	150	1883	"	100	1883	"	"	1883
WW-14	E. Buffalo	Yard Office	Water Works	City	8c per 1000 Gal.	8.63	Unlmt.	60,000	"				"				6"	30	1893			
"	"	Eng. House	"	"	"	"	"	60,000	"				"				8"	800	"			
	Buffalo	W.S. Dock	Blackwell Canal	"	"	"	"		one 12x24	15,000	10'	1903	"	6"	65'	1903				12x16	"	1903

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—WEST SHORE, WESTERN DIVISION.

Division Engineer

Pump House & Equipment									Boiler							Columns							— Remarks —
Kind	Size	Capy. Per Hr.	Lift	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No.	Kind	Size	[illegible]	[illegible]	[illegible]	[illegible]	No.	Kind	Size	Lift of [illegible]	Height above [illegible]	Date Made	Date Set	
																1	[illegible]	7"	8'6"	[illegible]	1874		
																1	"	"	"	"	"		
																1	"	"	"	"	"		
[illegible] / 1 Fairbanks	[illegible]	33000 / 15000	8' / 8'	[illegible] / 10		6" / 6"		1883 / 1901	[illegible]	Upright / Horiz.	12 H.P.	[illegible]		1901		2	[illegible]	10	7'8"	"	1909		
1 Fairbanks / [illegible]	[illegible] / 35	39000 / 23000	10 / 18	60 / 60		6 / 6		1908 / 1899	377	Upright / [illegible]	[illegible]	"		1908 / [illegible]		2	[illegible]	10	7'-6"	"	1906		
1 Fairbanks / 15 [illegible]	[illegible] / 25	39000 / 23000	10 / 12	60 / 100		6"		1908 / 1883	83	"	16 H.P.	"		1907 / 1903		2	"	"	"	"	1907		
"	35	23000	10'	20		6"		1883	475	"	16 HP	"		"		2	"	"	"	"	1883		
																1	[illegible]	7	"	"	1903		
"	35	23000	12'	20		6"		1883	79	"	16 HP	"		1906		2	[illegible]	10	"	"	1908		
"	"	"	"	60		"		1882	421	N.Y.C. [illegible]	12 HP	"		1901		2	"	"	"	"	1908		
[illegible] Gasoline	[illegible]	39000	10 / 20	60 / 150		"		1906								1	"				1908		
Two [illegible]	[illegible]	Two 25000	10'	50		Two 6"		1901	380 / 381	[illegible]	Two [illegible]	100		1901		2	[illegible]	10"	8'6" / 7'-6"	"	1901		
[illegible]	35	23000	10'	50		6"		1883	82	Upright [illegible]		60		1883		2	[illegible]	7	8'6"	"	1883		
"	"	"	10'	70		6"		1895	459	[illegible]	12 HP	"		[illegible]		"	"	"	"	"	"		
					50																		
"	35	23000	8'	250		6"		1892	80	Upright	[illegible] HP	60		1892		2	"	7	8'6"	"	1892		
"	"	"	14'	50		"		1883	84	Upright	[illegible] HP	60		[illegible]		"	"	"	"	"	1883		
																1	"	"	"	"	1893		
																2	"	"	"	"	1883		
"														1903		1	Tank Spout				1903		Gasoline

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—MAIN LINE, WESTERN DIVISION.

No	Station	Location	Water Supply: Source	Owner	Rent	Quality Per Gal	Daily Cap	Daily Con	Tank or Reservoir: Size	Cap	Height above B of R	Year Built	Trough	Pipe: Supply to Tank: Size	Length	Year Laid	Tank to Column: Size	Length	Year Laid
	Minoa	Eng. Ho.	Lime Stone Cr.	State		Fair	Unl't'd	700000	2-16x24	Two 50000	20'	1905		6"	3000	1904	12"	1000	1904
YY-1	Dewitt	"	Butternut Creek	"		"	"	893000	Two 16x24	Two 50000	20'	1902	None	8"	6000	1902	12	1000	1902
"	"	Pump Ho.	"	"		"	"	"	"	"	One 20'	1902	"	8" 6"	40' 1800	1885	8 10	1300	1900
YY-2	Syracuse	Eng Ho.	Water Works	City		Good	"	420000	"	50000	16'+26'	1895 1903	"	6 6	2250 775	1889 1903	12	1500	1902
YY-3	Belle Isle	At Track		State		Fair		165000					"				12	672	1900
YY-4	Weedsport	"	Seneca River	"		"	6280		16x24	50000	20'	1903	"	6	750	1903	12	120	1903
YY-5	Fox Ridge	"	"	"		"	Unl't'd	350000	One 16x24	"	21'	1903	Two 1400	Two 8	160	1903	12	130	1902
YY-6	Clyde	"	Clyde River	"		"	"	49000	"	"	20'	1901	None	8	300	1901	12	275	1901
YY-7	Lyons	Coal Trestle		"		"	"	370000	Two 16x24	Two 50000	Two 30'	1901	"	8	1000	1907	12	360	1901
"	"	"	Water Works	City		"	"	"						3	105	1901			
YY-8	E. Palmyra	At Track	Mud Creek	State		"	"	450000	Two 16x24	50000	21'	1894	Two 1400	Two 6	Two 94	1894 1900	12	160	1902
YY-9	Fairport	"	Roch. & Lake Ont. Water Co.	Roch. & Lake Ont. W. Co.		Good	"	85000									12	400	1903
YY-10	E. Roch	Eng. Ho.	"	"		"	"	270000	Two 16x24	Two 50000	20'	1905	None	8	175	1905	12	1020	1901
"	"	West End of Yard	"	"		"	"	35000	One 12x14	15000	20'	1902	"	4	130	1905	6	136	1902
YY-11	Rochester	Pass Sta.	"	"		"	"	25000 58000	Two 16x24	Two 50000	21'	1902	"	4	50 30	1903	8	173 120	1882 1902
YY-12	" Coldwater	Town of Gates At Track	" Springs	" State		" "	" "	56000 115000	One 12x20 One 16x24	30000 50000	20 9'	1907 1891	" "	3 6	[illegible] 200	1907 1888	12 12	126 675	1907 1901
YY-13	Churchville	"	Snyder's Springs	N.Y.C. & H. R. R.R. Co.		"	300,000	175000	"	"	19'	1888	Two 1400	6	1260	1901	6" 12"	725 100	1888 1901
YY-14	Byron	"	Godfrey's Pond	"		"	Unl't'd	85000	One 12x20	30000	12'	1900	None	8	13068	1900	12	150	1900
	Batavia	East End of Yard	Tonowanda Creek	State		"	"	210000	One 16x24	50000	16'	1891	"	6	3250	1899	12	250	1903
"	"	Pass Sta.	"	"		"	"	"	"	"	20'	1903	"	6	1457	1899	12 12	500 412	1903 1903
"	"	West of Eng. Ho.	"	"		"	"	"	"	"	20'	1902	"	6	550	1899	12	425	1902
YY-16	Wende	At Track	Lake Erie	Depew & L. E. Co.		"	"	297000	Two 10x20	"	26'	1888 1907	Two 1400	6	30	1900	12	260	1901

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—MAIN LINE, WESTERN DIVISION.

Division Engineer

Pump House and Equipment: House Size	House Kind	House Year Built	Pump Kind	Pump Size	Pump Cap'y per hour	Height Lift	Height Disch.	Gravity Head	Size Intake	Date Made	Date From Shop	Boiler No.	Boiler Kind	Boiler Size	Steam Capacity	Date Built	Date From Shop	Tested	Columns No.	Columns Kind	Columns Size	Length of Arm	Height above B of R	Date	~Remarks~
13'x18'	Wood	1904	Two Fairbanks	12x7x10 [illegible]	30000	9'	28'		8"		1904	4 23	Two upright	Two 40 H.P.			Mar. 1907		3	Sheffield	10"	7'8"	10'0"	1904	
35'x46'	Brick	1900	One Worthington	18x10x12	50000	10'	22'		"		1902	387	3 Loco	2 35 H.P.	100 HP		1898 1906		6	"	10"	"	11'0"	1902	
"	"	"	Two Fairbanks	[illegible]	"	"	"		"		"	26 624 225	..	..			1904 "		1	"	"	"	"	..	
																			3	"	"	"	"	..	
W. S. Pump House + Pump and Tank see Amboy																			3	"	"	"	"	1900	
14'x22'	Brick	1903	Two Worth	#7 10x6x10	9000	13	13		6"		1903	585	one upright	45 H.P.	100 HP		1903		3	"	"	"	"	1903	
36'x38'	"	1903	Two Fairbanks	2 10x7x12	2 20000	12	100		6"		1903	598 599	Two loco	2 100 HP	125		1903		4	"	"	"	"	1902	
W. S. Pump across River																			2	"	"	"	"	1901	
36'x79'	Brick	1901	Two Worthington	8x12x[illegible] 8½x10	2 30000	10	18		6"		1901	57 58 59	3 loco Trade	3 40 H.P.	3 100		1901		1 3	V. Verst Sheffield	8" 10"	" "	" "	" "	
			Dean	8x12	30000	10	18		6"		1905														
28'x50'	Frame	1894	1 Fairb's 1 Knowles	10x8x12 #10	2 30000	19	400		2 6"		1-1894 1-1901	53 390	2 loco	2 100 HP	100		1897 1900		3	Sheffield	10"	"	"	1902	
																			1	"	"	"	"	1903	
																			4	Sheffield	10"	"	"	1901	
																			1	Hose Connection	6"	15'	"	1902	
																			1 1	Sheffield V. Verst	10" 8"	7'8" 7'8"	11'6" 11'0"	1907 1882	
16'x24'	Frame	1878	1 Fairb's 1 Knowles	7x5x10 #7	2 9000	10'	16'		6"		1901 1898	392	one upright	25 HP	100		1901		2 3	Sheffield "	10" 10"	" "	11'6" 11'0"	1907 1901	Kent St. one Van Verst Column
W. S. Pump + House																			3	"	"	"	"	"	
12'x18'	Frame	1883	One Fairbanks	7x4½x10	10000	12'	16'	26'	4"		1900	42	N.Y.C. H.R.	12 HP	80				1	"	"	"	"	1900	
	Brick	1873	1 Fairb's 1 Knowles	10x6x12 #8	2 12000	12	100		2 6"		1898 1899		one loco	100 HP	100		1903		1	"	"	"	"	1903	
	"	"	"	"	"	"	"		"		"		"	"	"		"		2	"	"	"	"	"	
	"	"	"	"	"	"	"		"		"	563	"	"	"		"		1	"	"	"	"	1902	
23'x36'	"	1901	One Fairbanks	12x8x[illegible]	39000	22'	90'		6"		1901	398 399	1 Loco 1 upright	100 HP 20 HP	125 125		1901 1901		3	"	"	"	"	1901	

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R.—R. W. & O. DIVISION.

			Water Supply.						Tank or Reservoir.					Pipe.					
No	Station	Location.	Source.	Owner	Cost.	Quality †	Daily Capac.	Daily Consum	Size	Capac. Gals.	Height above T or R	Year Built	Trough	Supply to Tank Size	Length	Yr Laid	Tank to Column Size	Length	Yr Laid
R-1	Salina	at track	Water Wks	City of Syracuse		678	Unlim	28000									4"	180'	1901
R-2	Brewerton	at track	Oneida R	State		1005	Unlim	10000	16'x24'	50000	20'	1903		4"	252'	1903	12"	72'	1903
R3	Maple View	at track	Spring	R.R.		Hard	9000	8000	16'x24'	50000	25'	1896		3"	125'	1905	12"	396'	1905
R4	Richland.	100' S. of N. Wye	Well	R.R.		935	Plenty	100000	16'x24'	50000	23'	1898		3"+6"	60' 60'	1898	8" 12"	84' 400'	1896
R5	Pierret Manor	at track	Springs			1176	Plenty	20000	16'x24'	50000	22'	1903		6"	1250'	1903	12"	84'	1903
R6	Adams	at track	Water Wks	Village		1075	Unlim	28000	16'x24'	50000	24'	1903		6"	872'	1903	12"	298'	1903
R6A	Rices	at track	Creek	State			Plenty	10000	16'x24'	50000	14'	1904		3"	50'	1903			
R7	Watertown	at Jct & Engine Station	River Water Wks	State City	Metered	350	Unlim		16'x24'	50000	22'	1903		8" 12"	2197 410	1906 1907	12" 8" 12"	200 30 130	1903
R8	Philadelphia	at track	Creek	State		634	Unlim	60000	20'x30'	95000	24'	1906		3"+6"	125'	1906	12"	300'	1906
R9	Gouverneur	at track	Water Wks	Village		402	Unlim	44000	16'x24'	50000	22'	1904		3"	125	1904	12"	110'	1904
R10	DeKalb	at track	Well	R.R.		2590	Plenty	40000	16'x24'	50000	24'	1893		3"	50'	1890	8"	100'	1890
R11	Potsdam	at track	Water Wks	Village	$500 Per Yr	380	Unlim.	50000	16'x24'	50000	22'	1891		3"	200'	1891	8"	250'	1891
R12	Norwood	Engine Hse	Water Wks	Village	$500 Per Yr	451	Unlim	44000	16'x24'	50000	22'			4"	850'	1902	8"	150'	1895
R13	Massena	Engine Hse	Water Wks	Village	$400 Per Yr	727	Unlim	30000	16'x24'	50000	22'	1905		3"	750'	1902	8"	300'	1897
R01	Burt	at track	Creek	State		1400	Unlim	27000	16'x24'	50000	22'	1902		3"	1150'	1902	10"	250'	1902
R02	Lyndonville	at track	Creek	State		1125	Unlim	20000	16'x24'	50000	24'	1903		3"	550'	1892	12"	125'	1903
R03	Morton	at track	Well	R.R.		1291	9000	9000	16'x24'	50000	21'	1894		3"	300'	1894	8"	100	1894
R03½	Morton	2 Miles East	Sandy Crk	State		1167	Unlim		14'x20'	30000	14'	1903		3"	100'	1903	8"		
R04	Charlotte	at track	Water Wks	[illegible]			Unlim	53000	16'x24'	50000	22'	1897		6"	800'	1905	8"	270'	1901
R05	Charlotte	at Engine Hse				1258													
R06	Lakeside	at track	Mill Pond	Mrs [illegible]	$100 per yr	1384	Plenty	20000	16'x24'	50000	22'	1902		3"	90'	1902	10"	220'	1902
R07	Wallington	at track	Creek	State		1344	Unlim	45000	16'x24'	50000	22'	1895		3"	2000'	1895	8"	70'	1895
R08	Red Creek	at track	Creek	State		1175	Plenty	20000	16'x24'	50000	22'	1902		3"	350	1902	10"	85'	1902
R09	Oswego	at Shops	Water Wks	City	$150 Per Mo	1803	Unlim	70000	16'x24' 16'x20'	50000 35000	25' 20'	1904 1893		4"	250' 300'	1888 1893	8" [illegible]	[illegible]	[illegible]
R010	Mexico	at track	Creek	State		557	Unlim	10000	16'x24'	50000	22'	1902		3"	50'	1902	10"	180'	1902
RW1	Rochester	at track	Water Wks.	City		573	Unlim	600	16'x20'	30000	14'	1900		3"	200'	1899	8"		

† Quality given as Total Solids (in Grains) per gal

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R. R.—R. W. & O. DIVISION.

Pump House and Equipment: House Size	House Kind	House Year Built	Pump Kind	Pump Size	Pump Capac. per Hr.	Pump Height Lift	Pump Height Dis.	Gravity Head	Size Intake	Pump Date Made Set	Boiler No.	Boiler Kind	Boiler Size	Boiler Steam Capac.	Boiler Date Made Set	Boiler Tubes	Columns No.	Columns Kind	Columns Size	Lgth. of Arm	Height above T. of R.	Date Model	Date Set	Remarks
																	1	Poage	8"	8'	11'	1898	1902	Note Columns [illegible] are [illegible]
18x24	Wood	1904	F-M Co	10x6x12	12000	12	32'		6"		286	Ames Loco	10HP	60			1	Poage	8"	7'8"	10'8"	1895	1887	[illegible]
18x24	Wood	1900	Kingsford	7x4½x10	3000	7'	28'		3"		305	Kingsford Loco	10HP	60lb			1	Poage	8"	7'9"	11'	1895	1905	
50x32	Brick	1906	F-M Co / Cameron	10x6x12 / 8x9x10	12000 / 7000	15'	24'		3"+4"		311 / 301	Loco	75HP	125			2	Poage	8" / 8"	7'6" / 7'9"	10'8" / 11'	1895	1898 / 1906	
16x30	Wood	1901	F-M Co Gasolene	8HP	9000	6'	40'		6"								1	Poage	8"	7'6"	11'	1895	1887	
																	1	Poage	8"	7'9"	11'6"	1895	1885	Village Supply.
12x16	Wood	1903	Kingsford	7x4½x10	3000	6'	16		3"		329	Upright Fitch	10HP	60										Spout Tank
16x26	Wood	1907	2 F M Co	14x7x12 / 10x6x12	16350 / 12000	18'	49'		8" / 6"	1907	519 / 523	Loco.		100 / 100			3	Poage	8"	7'9"	[illegible]	1898	[illegible]	
14x30	Wood	1903	Fairbanks / Kingsford	10x6x12 / 7x4½x10	12000 / 3000	10'	28'		6" / 3"	1903	52 / 317	Ames Loc / Lidgerwood	25HP / 15	90			2	Poage	8"	7'9"	10'10"	1895	1892	
																	1	Poage	8"	7'9	11'	1895	1886	
18x24	Wood	1890	F-M Co / Knowles	10x6x12 / 8x4¾x10	12000 / 3800	12'	25'		4"		615	Ames Upright	25HP	100			1	Poage	8"	7'9"	11'	1895	1893	
																	1	Poage	8"	7'9"	10'10"	1895	1891	
																	1	Poage	8"	7'9"	10'11"	1898	1896	[illegible]
																	1	Poage	8"	7'9	10'10	1898	1894	
14x16	Wood	1904	F M Co / Kingsford	10-6-12 / 7x4½x10	12000 / 1500	8'	80'		4"+3"		658	Upright	25HP				1	Poage	8"	7'6	10'9"	1895	1884	
20x24	Wood	1895	1 Kingsford / 1 Dayton	7x4½x10 / 10x7x5	3000 / 8000	14'	60'		3"		315	Ames Loco	10HP	60			1	Poage	8"	7'6	10'9"	1895	1884	
14x20	Wood	1894	Kingsford	7x4½x10	3000	10'	30'		3"		300	Ames Loco	10HP	60			1	Poage	8"	7'6"	10'9"	1895	1892	
12x18	Wood	1903	Kingsford	7x4½x10	3000	8	20'		3"		303	Kingsford Loco.	10HP	60					8"	7'6"	12'6"		1903	*Spout Tank
8x24	Wood	1897															1	Poage	8"	7'6"	11'0"	1895	1897	Village Supply
			1 Kingsford / 1 Knowles	7x4½x10 / 8x4¾x10	3000 / 3300	10 / 10	12 / 12				735	Simmons [illegible]	150 HP	100										used for washing out Boilers & pumping direct into Engine House
14x24	Wood	1902	Kingsford	7x4½x10	3000	12'	20'		3"		314	Kingsford	10HP	60			1	Poage	8"	9'0"	10'10"	1898	1902	
14x20	Wood	1895	Kingsford	7x4½x10	3000	12'	40'		3"		383	Ames Upright	25HP	100			1	Poage	8"	7'8"	10'11"	1895	1895	
16x28	Wood	1900	Kingsford	7x4½x10	3000	16	40'		3"		654	Titusville Upright	25 HP	100			1	Poage	8"	7'8"	11'3"	1895	1881	
																	3	Poage	8"	[illegible]	[illegible]	1895	1888	
15x25	Wood	1902	Kingsford	7x4½x10	3000	14'	35'		3"		287	Kingsford Loco	10HP	60			1	Poage	8"	7'6"	11'0"	1895	1885	
																			8"	9'0"	12'6"			*Spout Tank

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R.—R. W. & O. DIVISION.

			Water Supply.						Tank or Reservoir.					Pipe					
														Supply to Tank			Tank to Column		
No.	Station	Location	Source	Owner	Cost	Quality (See note Sheet 1)	Daily Capac.	Daily Consum.	Size	Capac. Gals.	Ht. above T. of R.	Yr. Built	Trough	Size	Length	Yr. Laid	Size	Length	Yr. Laid
RP1	Phoenix	at track	Water Wks.	Village	$150 Per Yr.	2139	Unlim.	3200									4"	100'	1887
RR1	West Camden	at track	Creek	State		542	Unlim.	42000	16'x24'	50000	23'	1903		6"	100'	1903	10"	72'	1903
RR2	Blossvale	at track	Well	R.R.		484	Plenty	9000	16'x24'	50000	20'	1895		3"	55'	1896	8"	195'	1896
RY1	Limerick	at track	Well	R.R.		1114	Unlim.	4000	16'x24'	50000	14'	1893		3"	100'	1893	8"		
RY2	Cape Vincent	Engine Hse.	Water Wks.	Village	$40 Per Yr.	816	Unlim.	6800	16'x24'	50000	14'	1890		3"	75'	1898	8"		
RG1	Edwards	at track	Oswegatchie R.	Woodcock Bros.	$150 Per Yr.	306	Unlim.	1500	16'x24'	50000	12'	1890		2"	1000'	1890	8"		
RU1	Utica	at track	Mohawk R.	State		1283													
RU2	Barneveld	at track	Creek	State		1127	Unlim.	3000	16'x24'	50000	22'	1894		6"	2500'	1902	8"	50'	1894
	Remsen	at M & M track	Spring			1128	Lim.												
RU3	Smith	at track	Water Wks.	Village	0.037	7.14	Unlim.										6"	150'	1905
RU4	Lyons Falls	at track	Water Wks.	Village	$150 Per Yr.	570	Lim.	5000	16'x24'	50000	22'	1900		2"	50'	1900	8"	75'	1900
RU5	Lowville	at track	Water Wks.	Village	$300 Per Yr.	242	Plenty	10000	16'x24'	50000	24'	1894		2"	250'	1894	8"	125'	1894
RU6	Carthage	Engine Hse.	Black River	State		545	Unlim.	70000	16'x24'	50000	22'	1892		6"	40'	1902	8"	350'	1892
RU8	Redwood	at track	Mud Lake	State		3.56	Unlim.	4000	16'x24'	50000	14'	1890		3"	110'	1890	8"		
RU9	Morristown	at track	St. Lawrence River	State		8.16	Unlim.	12000	16'x24'	50000	20'	1892		3"	45'	1892	8"	50'	1892
RU10	Ogdensburg	Engine Hse.	Water Wks.	City	$100.00 Per Yr.	4.58	Plenty	57000	16'x24'	50000	24'	1906		4"	377'	1906	12"	611'	1906
RF1	Clayton	Engine Hse.	St. Lawrence River	State		8.51	Unlim.	6000	16'x24'	50000	30'	1893		3"	125'	1893	8"	125'	1893
RC1	Diana	at track	Springs	R.R.		527	Lim.	850	16'x24'	3000	12'	1906		2" 3"	[illegible]	1890 [illegible]	8"		
RC2	Jayville	at track	Well	R.R.		577	Unlim.	3000	16'x24'	50000	14'	1883		3"	30'	1883	8"		
RC3	Benson Mines	Magnetic Iron Ore Co. Plant	Creek	Mag. Iron Ore Co.	$200 Per Yr.	4.55	Unlim.	3000	16'x24'	50000	14'	1883		6"	75'	1883	8"		
	Newton Falls	Engine Hse.	Well	R.R.			Plenty					1904							
	Felts Mills	at track	Creek	State			Unlim.		14'x20'	30000		1906		3"					
	Alder Creek	at track	Gravity	A.S. Brewer		5.72	Lim.		Two 7x12	6200 Each	10'	1874		3" 2½"	1000 1000	1882 1874	6"		
	Model City	at track	Well	R.R.					14'x20'	30000		1905		3"					

LOCOMOTIVE WATER SUPPLY STATIONS.

N. Y. C. & H. R. R.—R. W. & O. DIVISION.

House: Size	House: Kind	House: Yr. Blt.	Pump: Kind	Pump: Size	Pump: Cap. Per Hr.	Pump: Height Lift	Pump: Disc.	Gravity Head	Size [illegible]	Date Made	[illegible]	Boiler: No.	Boiler: Kind	Boiler: Size	Steam Cap.	Boiler: Date Made	[illegible]	Tests	Columns: No.	Columns: Kind	Columns: Size	Lgth of Arm	Ht Above Top R.	Date Model	Date Set	Remarks
																			1	Poage	8"	7'6"	10'6"		1887	
18x24	Wood	1890	Fairbanks	10x6x12	12000	10'	25		6"	1903		655	Phoenix Upright	25HP	100				1	Poage	8"	7'5"	11'		1886	
18x24	Wood	1895	Kingsford	7x4½x10	3000	9'	30		3"			319	Ames Loco.	10HP	60				1	Poage	8"	7'10"	10'6"		1895	
12x18	Wood	1893	Kingsford	7x4½x10	3000	12'	30		3"			293	Ames Loco.	10HP	60						8"	9'0"				*Spout Tank.
																					8"	9'0"				*Spout Tank
																					8"	9'0"				*Spout Tank
																										Maintained by Mohawk Div.
13x18	Brick	1902	F.M.Co. Gasoline	12HP	10000	15	140		6"	1902									1	Poage	8"	7'9"	11'2"	1894	1898	
																			1	Poage	8"	7'9"	11'	1898	1903	Water from N & M tank
																			1	Best Mfg. Co.	8"	7'9"	11'		1905	Village Supply
																			1	Poage	8"	7'9"	10'11"	1898	1900	
																			1	Poage	8"	7'9"	10'11"		1894	
18x34	Wood	Rebuilt 1902	Worthington	10x7x12	12000	15'	28		6"	1902		257	Unknown Loco.	75 HP	100				2	Poage	8"	7'9"	10' N.W. 11'1" E.		1892	*Spout Tank
18x24	Wood	1900	Kingsford	7x4½x10	3000	10'	20					316	Ames Loco.	10HP	60						8"	9'0"				[illegible] abandoned [illegible]
18x24	Wood	1885	Kingsford	7x4½x10	3000	17'	20		3"			318	Kingsford Loco.	10HP	60				1	Poage	8"	7'9"	10'11"		1892	
																			1	Poage	8"	7'9"	10'11"		1891 1906	
16x33	Wood	1902	Kingsford	7x4½x10	3000	18'	30		3"			670	Ames Upright	25	100				1	Poage	8"	7'9"	11'0"		1893	
								40'													8"					*1 Spout Tank
18x28	Wood	1883	Kingsford	7x4½x10	3000	10'	18					325	Kime's Loco.	10HP	50						8"	9'0"				*Spout Tank.
																					8"	9'0"				*Spout Tank.
Pump in Eng. Hse.			Kingsford	7x4½x10	3000				3"			Steam from Loco's.														
16x24	Wood	1906	"	"	"	15	30		3"			326	Kingsford Loco.	10HP												Spout Tank
																										Spout Tank
16x24	Wood	1905	Kingsford	7x4½x10	3000	17	12		3"			309	Kingsford Loco.	[illegible]												Spout Tank

* Upper figures denote Grains scale forming solids in one U. S. Gallon of water.
Lower " " " soluble " " " " " " " "

2248.

DISCUSSION.

Mr. C. L. Ransom (Chicago & Northwestern):—The Committee on Water Service has endeavored to present elementary principles of water service in as precise manner as it was possible for them to do and presents for publication in the Manual the elementary principles, so that more elaborate work can be done a little later, and the Committee asks that the Association pass first on the definitions on page 178, and, secondly, on the conclusions on pages 212 to 219, of Bulletin 107.

The Secretary:—"Definitions—Pipe Lines:

"Suction Line—Leading from the pump to the source of supply.

"Discharge Line—Leading from the pump to the storage tank.

"Column Supply Line—Leading from the storage tank to water column.

"Storage Tank, consisting of:

"Foundation—That portion below ground line.

"Substructure—That portion resting on foundation and supporting the tub.

"Tub—The receptacle holding the water.

"Outlet Valve—The valve in bottom of tub controlling the delivery of water direct to locomotives.

"Spout Outlet—The pipe leading from the outlet valve to the tank spout.

"Tank Spout—The movable device for delivery of water from the spout outlet to the locomotive.

"Track Pan—Device for taking water while locomotive is in motion."

The President:—It is understood that definitions will not be discussed on the floor of the house, but any member who takes exception to them can do so in writing. The Secretary will read the conclusions, and as they are read, if there is no objection they will be considered as approved.

The Secretary:—"Supply, Quantity.—If possible within economical limits, supply should be obtained sufficiently large so that the total amount of water likely to be required during the average volume of business in 24 hours can be drawn from the source in 7 hours at terminal stations and in 4 hours at intermediate stations."

Mr. C. E. Lindsay (New York Central):—I think the word "maximum" instead of "average" would be better.

Mr. Ransom:—The word "average" was used for the reason that the Committee thought we needed some latitude on account of the

excessive volume of business at certain times of the year. Therefore the wording was put in as it is.

Mr. C. F. Loweth (Chicago, Milwaukee & St. Paul):—Why should the entire supply for twenty-four hours be pumped in four hours? This would require a very much larger pump and pipe connections than would otherwise be necessary, and frequently make the pumping plant an expensive one.

Mr. Ransom:—I will refer the gentleman to the conclusions on page 219, in which the method of operation is recommended, and there you will find the recommendation that regular pumpers be employed, instead of other employes. The reason that recommendation was made was that a regular pumper would have a chance to pump at one station and then go to another.

Mr. Loweth:—There are frequent occasions where the water stations are so far apart, and the train service so infrequent or such that one pumper cannot attend to more than one station.

The Secretary:—"Supply, Source.—Where water of suitable quality, and in sufficient quantity, can be purchased at a reasonable figure, it is recommended above all other sources.

"Springs should be carefully gaged for a period of at least one year and the possibility of future pollution and increased demands for supply therefrom carefully considered before their adoption as a permanent source. Reservoir should be constructed at spring where conditions will permit.

"Lakes, natural ponds, creeks or rivers require special investigation in each case. Points to be considered are quantity, quality as regards chemical impurities and amount of sediment carried, future pollution and riparian rights. Style of intake will depend on local conditions entirely. No definite rules can be given.

"Dug well construction should always be preceded by a careful auger test to determine strata to be encountered. Size and construction depend on strata to be passed through, and no definite rule can be given.

"Surface pipe wells are very satisfactory where local conditions permit of their use. The system is one which can be extended to collect a large volume of ground waters.

"Artesian deep wells, where obtainable, are very satisfactory sources. Their flow is liable to constantly decrase and finally stops altogether.

"Deep wells requiring pumping are only recommended as a last resort.

"A chemical analysis of all waters should be made and the question of cost of treatment if required thoroughly investigated, as previously outlined in the Manual.

"Pumping Plants.—Size of plant should be in accordance with table given on page 213, Bulletin 107.

"Static head should be obtained. Friction head should be calculated in accordance with friction tables and 50 per cent. added thereto for the aging of the piping system.

"The effective horsepower will be

$$\frac{\text{Gallons per minute} \times \text{static head} + \text{friction head in feet.}}{4{,}000}$$

"Steam should be selected for power plants up to 5 E. H.P. when most of the following conditions obtain:

"(A) Where one hundred pounds of coal unloaded into a pump house is cheaper than one gallon of gasoline delivered at gasoline storage tank, taking into consideration the number of hours the plant is to be operated and the location of plant as regards delivery of fuel; special attention also being paid to the proper design of pump as regards size of steam and water cylinders on large plants.

"(B) Where a steam plant is maintained for other purposes, as at terminals where shops are run by steam.

"(C) Where interest charge on plant is less than it would be on a gasoline plant."

Mr. Ransom:—The Committee, since this report was made up, has received some criticism of the speed at which this recommendation is made out. If there are any members of the Association who would like to talk on that, we would be pleased to hear from them. This was a recommendation from a man who has been in the pumping business a good many years, and the Committee feels possibly it is a little too conservative.

Mr. A. K. Shurtleff (Chicago, Rock Island & Pacific):—I cannot see why we should not use 3,960; 3,960 is a little more accurate mathematically. In a large plant 3,960 would be more correct than 4,000.

Mr. Ransom:—The Committee will accept that suggestion.

The Secretary:—"Boiler selected should have the relation to E. H.P. as shown by Appendix I, and should carry 100 lbs. steam.

"Steam pump selected should have the ratio of water to steam cylinders as large as possible. Water cylinder should be of proper size to discharge the required amount of water per minute, assuming 70 strokes per minute for each cylinder. Pump efficiency should be assumed as 66⅔ per cent. Initial steam pressure, 90 lbs. per square in. Proper ratio of water to steam cylinder should be as per diagram 4. Size of steam cylinder should be in accordance with this size of water cylinder and ratio (see diagram 3, Appendix H).

"Gasoline engine selected should have a commercial brake horsepower rating of twice the effective horsepower. Engine and gearing for reduction of speed should be all on one base, with friction clutch connection to pump shaft.

"Power pump, where suction lift is such that the pump can be on same level as engine, may be of the triple single-acting type, or duplex double-acting, direct-connected to engine friction clutch. For small plants the combined engine and pump are recommended.

"Power pump, where suction lift is such that the pump must be at a lower level than engine, should be single cylinder, double-acting type, connected to engine by means of a pitman face-plate and shaft. Number of strokes per minute, pitman and stroke length should be as follows:

12. in. Stroke, Pitman length, 6 ft., No. Strokes per minute 70.
18 in. Stroke, Pitman length, 6 ft., No. Strokes per minute 46.
24. in. Stroke, Pitman length, 8 ft., No. Strokes per minute 35.
30. in. Stroke, Pitman length, 10 ft., No. Strokes per minute 28.
36. in. Stroke, Pitman length, 12 ft., No. Strokes per minute 23.

"Deep well pumping plants, where gasoline driven, should have same proportion of stroke pitman and number of strokes per minute as above. When steam driven, the proportions should be as follows:

Stroke 12 in., No. Strokes per min. 60, No. Cylinder discharges 30.
Stroke 18 in., No. Strokes per min. 40, No. Cylinder discharges 20.
Stroke 24 in., No. Strokes per min. 30, No. Cylinder discharges 15.
Stroke 30 in., No. Strokes per min. 24, No. Cylinder discharges 12.
Stroke 36 in., No. Strokes per min. 20, No. Cylinder discharges 10.

"Size of gasoline engine and steam head should be in same ratio as for surface pumps."

Mr. Ransom:—The Committee feels that this recommendation really requires more investigation before it is published in the Manual, and if the Association so desires, we would request that these two tables be referred back to the Committee for further report next year, if there are no members of the Association who can give us any light on the subject.

The Secretary:—"Pump houses should be of non-combustible material. In gasoline plants engine should be in a room by itself, with floor vents. Stoves should not be permitted in gasoline engine rooms. Where there are deep wells, the house should be so designed that it can be removed or opened to admit of a well machine being placed over it. At terminal stations the pump house should be incorporated with other part of plant where possible.

"Each plant should be fitted with a pressure gage on discharge pipe and a revolution counter on pump."

Mr. Lindsay:—I would like to ask if the Committee will add the words "and lights" after "stoves"—stoves and lights shall not be permitted in the house," and also a statement to be inserted that the gasoline supply shall be kept outside of the house.

Mr. Ransom:—I do not exactly see how you can exclude lights from the house. If a man has to run his engine at night he has to have some light, to see whether his oil cups are full.

Mr. Lindsay:—We put our lamp outside so that it throws the rays of light inside.

Mr. Ransom:—The Committee will accept that suggestion.

Mr. L. C. Fritch (Illinois Central):—I would like to know what the Committee means by the last sentence, "at terminal stations the pump house should be incorporated with other part of plant where possible." Does it mean the other part of the terminal plant?

Mr. Ransom:—Yes, sir.

Mr. L. C. Fritch:—A fireproof pumping house should be isolated and not incorporated with another plant. If it is incorporated with some other plant, when the other plant catches on fire the pumping house may be destroyed.

Mr. Ransom:—The thought of the Committee was, where you have a steam plant, and already have steam in your shop, in order to prevent loss by condensation you would want the pumping plant as near the steam supply as possible; you would not want to maintain separate boilers for the pumping plant, as a matter of economy.

Mr. Maurice Coburn (Vandalia Lines):—It seems to me that the Committee, in discussing this question, should have something to say about pumping by electricity where you can use an automatic start and stop, and that the question of a steam turbine with centrifugal pumps should be considered.

Mr. Ransom:—I will say in regard to that, in the body of the report the Committee specifically states that for this reason only data on steam and gasoline plants were attempted. We were unable to get any information on any other class of power that enabled us to make any decisions, and we have recommended to the Board of Direction that the question of electrical and other styles of pumps be taken up by the future Committee; so that this report deals only with steam and gasoline.

Mr. Coburn:—I also suggested steam turbines.

Mr. Ransom:—The steam turbine question has not come up at all. We have no knowledge where any plant of that character is located for railroad use, and of course for municipal pumping the plants are so large that the Committee did not consider them.

The President:—The Secretary will now read the conclusions as to delivery to locomotives.

The Secretary:—"Methods of Delivery to Locomotives.—Function of Water Station.—(1) A water station, as an elementary proposition, consists of a supply of water, with means of delivering same to locomotive. This is done by gravity, except with Track Pans, where the same elementary arrangement is present with an added principle for completing the delivery in those special cases.

"Where the topography will permit full elevation the arrangement may consist of an elevated reservoir, excavated in the ground, with pipe line and water column.

"Where only partial elevation can be secured it may consist of a tub resting on the surface, with pipe line and water column.

"Where the topograhpy will not offer even partial elevation, same must be secured by artificial means, permitting of choice in location of

the supply, which is done by placing same (a) near the track, reducing the cost of delivery line, and (b) distant from the track, although at increased cost of delivery line.

"The prevailing topography makes artificial elevation necessary at a large majority of water stations, resulting in the structure known as a Storage Tank, which is subdivided, naturally, into its structural elements, on the same lines as those occasioned by varying topographical conditions, viz., Foundation, Substructure, Tub and Delivery Line.

"Storage Tanks.—(1) The foundation should be made of any good masonry locally available, provided it also withstands the disintegrating action of water.

"It should be carried below frost line and as much deeper as necessary to reach firm bearing, unless piles or other sub-foundations are used.

"(2) For substructure and joists the use of steel is recommended, Increasing the height of the substructure increases the discharge by less than the ratio between the square roots of the two heads. Increasing the size of the column supply line increases the discharge by more than the ratio between the squares of the two radii. The work of pumping, hence fuel consumption, is directly proportional to the head pumped against.

"Twelve-inch columns are practicable and in most cases sufficient with tub of 15 to 20 ft. above the rail, which is recommended as the most economical height.

"In special cases it may be more economical to use substructures higher than 15 to 20 ft. on account of the length of column supply line or because the source of supply is elevated, particularly when from a municipal plant.

"(3) Tub.—The life of white pine tubs used in the past does not exceed twenty years; the quality used at present is inferior and will have a life of less than twenty years; the price has been increasing rapidly, even with the use of inferior lumber. The life of cypress used in the past does not exceed twenty-five years, the quality at present is as good as in the past, and the price has been rapidly increasing. Further increase in the price of wood tubs is to be expected in view of the rapid depletion of forests. The use of wood in tubs limits the capacity of same.

"Specifications for 50,000 gallon White Pine Tubs.—Details.—(1) (a) The inside diameters shall be 24 ft. at the bottom and 23 ft. at the top. The staves shall be 16 ft. long. The tub shall be made of carefully selected white pine lumber, surfaced to 2¾ in., which is free from sap, shakes, unsound knots, or other imperfections which can cause leaks or will impair the durability of the tub. (All small black knots extending entirely through the plank shall be carefully bored and thoroughly plugged.) All staves shall be full length without splicing. Every joint shall be machine-made and perfect, and the stave joints

sawed on true radial lines, with due regard to top and bottom diameter of tub.

"(b) The crozing at bottom of staves shall be cut with proper regard for pitch of stave when in position, and circular in shape, so as to be completely filled by tub bottom when staves are driven up.

"(c) The outside of staves shall be surfaced convex so as to give a full bearing to hoop throughout the width of each stave.

"(d) The tub shall be provided with hoops, as shown on plan, with single bolt pressed steel draw lugs and bolts for tightening.

"(e) One extra stave and dowel pins shall be furnished with each tub. Every tub shall be set up at the factory and the bottom and corresponding stave marked and numbered before being knocked down for shipment. The location of the hoops shall also be marked on the staves.

"(f) Hoops should be of muck bar iron, 4 in. wide by $\frac{5}{16}$-in.. thick, spaced as shown on plan, furnished in three sections and equipped with one-bolt pressed steel lugs and bolts.

"(2) Roof may be of material and design to conform with available markets and other structures.

"(3) Wooden Storage Tanks.—The plan submitted in Appendix K is recommended as good practice.

"Steel Storage Tanks.—Steel tanks are recommended as good practice unless the character of water prevents their use. They have a life more than double that of wood and larger scrap value when dismantled; the first cost is not much greater than wood, while the cost for proper maintenance of either is about the same. Provision for increased storage can be made with steel tanks when first erected, the additional capacity to be obtained by making tank higher whenever necessary at small cost, compared with that of an additional wooden tank. Further merit of steel tanks is reflected in conclusion under Tub—kind of material, stated earlier. The Hemispherical Bottom Steel Tank with steel substructure is not used ordinarily except at terminals. Three types of steel tanks are used at intermediate water stations, viz., Flat-Bottom Tub on steel substructure, Hemiellipsoidal Bottom Tub, supported by steel posts around the outside, and a cylinder or mud-drum 5 or 6 ft. in diameter at the center of the bottom, the mud-drum serving as frostproofing for the tank and column supply lines, and as a settling basin for sediment which is washed out through blow-off valve.

"Standpipe Tub, consisting of a tub imposed directly on the foundation, the substructure being omitted. The portion below the water column nozzle acts as a settling basin for sediment, which can be readily washed out. This type may be used as a combined storage tank and water softener, the raw water and chemicals being introduced at the bottom, the treated water being drawn from upper portion by means of a floating intake.

"Tub Unit Capacity.—(1) The tub unit capacity at Intermediate Water Stations depends on the relation of consumption, cost of installation and operation. It is recommended that the unit be at least 50 per cent. greater than the maximum daily consumption when erected.

"(2) The tub unit capacity at terminals also depends on the relation of consumption, cost of installation and operation. The unit capacity in this case is particularly subject to local conditions and no general relation obtains between it and the consumption. Ordinarily the tub serves as an equalizer to take care of heavy and light periods during the 24 hours, and the unit is generally less than the consumption."

Mr. L. C. Fritch:—I would like to ask whether all these conclusions are to be embodied in the Manual, or whether this is simply information.

The President:—All that is in boldface type is intended to be embodied in the Manual.

Mr. J. B. Berry (Chicago, Rock Island & Pacific):—Does the Committee mean that the bottom of the tub should be 15 or 20 feet above the rail?

Mr. Ransom:—That was the idea; to have the bottom of the tub 15 or 20 feet above the rail.

Mr. Robert Ferriday (Cleveland, Cincinnati, Chicago & St. Louis):—I would like to say, since the report was published, we have looked further into the question of dimensions and would like to substitute the word "outside" for "inside." The conclusion would then read: "The outside diameters shall be 24 feet at the bottom and 23 feet 4 inches at the top. The staves shall be 15 feet 11 inches long." We have canvassed further and find that the tubs, as manufactured, will agree with these revised dimensions. We are also going to change the title of the specifications to show the actual capacity. This has not yet been calculated. The 16 by 24 foot tubs are spoken of as 50,000-gallon tubs, but the capacity is really less.

Mr. Shurtleff:—I ask the Committee why they have different diameters for the bottom and top of the tub? I have known for a number of years of tubs being successfully used of the same diameter throughout.

Mr. Ferriday:—It is not necessary at the present time; these dimensions conform with the majority of tubs as built. The tubs were tapered on account of the hoops originally having been fastened together without lugs and were driven on. The dimensions of the top could be changed, but it was the idea to draw these specifications, not to cover any radical change in the manufacturers' plans, but to agree with them.

Mr. Shurtleff:—I have found the manufacturers are willing to bid on a straight tub. There is no trouble about getting competition, and I cannot see why we should bind ourselves to what the manufacturer might wish to deliver.

Mr. Berry:—We have been building water tanks with straight staves for twenty years. It does not cost much more money to increase the capacity of the tub. Because some one has been doing something for a number of years does not compel us in a modern plant to adopt these ideas.

Mr. Ferriday:—We shall be glad to have a suggestion to change that. I believe the majority of the tubs that are being furnished are in accordance with the dimensions, and that was the reason they were selected, rather than recommend something different from those usually furnished.

The President:—The Association understands that unless some formal objection is made the paragraphs will stand.

Mr. Shurtleff:—I move that the specification for 50,000-gallon white pine tubs be changed to read "the inside diameters shall be 24 feet," leaving out the question of bottom and top.

Mr. W. F. Steffens (Carolina, Clinchfield & Ohio):—I want to inquire whether this matter is to be published in the Manual as it stands. Are we placing the Association on record as recommending a 50,000-gallon tank?

Mr. Ferriday:—That is the idea.

Mr. Steffens:—If that is the case, I hope we may open the argument as to the relative merits between a 50,000-gallon tank and a 60,000-gallon tank. A 60,000 capacity tank is secured by increasing the height of the staves 4 feet; in other words, we add 20 per cent. to the capacity of the tank at a relatively small cost.

Mr. Ferriday:—It was not recommended that this size be used, but it was recommended that these specifications be used for that size tub; nor was it intended to recommend white pine tubs, but it was intended to recommend that for 50,000-gallon white pine tubs these specifications were to be used.

(Mr. Shurtleff's motion was adopted.)

Mr. J. P. Snow (Boston & Maine):—Referring to paragraph (d) it says that the hoops shall be provided with pressed steel draw lugs for the purpose of being tightened. I think that requirement would confine us to the use of flat hoops, and if so, the paragraph should be modified so that either flat or round hoops could be used.

Mr. Ferriday:—The hoops on the recommended plan are flat. The Committee in their report state that the use of the half-round or semi-elliptical hoop involves what might be considered special shapes that were not ordinarily obtainable, and they felt by recommending the use of the muck-bar wrought-iron hoops, together with heavier hoops, that a sufficiently strong hoop would be provided, and the lugs were recommended in connection with these flat hoops.

Mr. Loweth:—I think this Association ought not to go on record as approving flat hoops exclusively. For about five years past the Chicago, Milwaukee & St. Paul Railway has been gradually going to

round hoops, and round hoops are now our standard on this road. Our experience has shown that the round hoops have many advantages over the flat hoops.

Mr. Jos. O. Osgood (Central Railroad of New Jersey):—The New Jersey Central has also been using round hoops as standard for several years.

Mr. C. H. Ewing (Philadelphia & Reading):—We have adopted the round iron hoops as standard and do not consider it safe to continue to use the old flat hoops, in view of the failures we have had on that account.

Mr. Lindsay:—I move the subject of tank hoops be referred back to the Committee for further consideration.

(Motion carried.)

Mr. L. C. Fritch:—It seems that paragraph (f) should go back to the Committee with paragraph (d).

Mr. Shurtleff:—I move that the entire specification for white pine tubs be referred back to the Committee, with the idea of leaving the dimensions blank in such way that the specification will cover any dimension of white pine tub that is used in practice.

Mr. M. L. Byers (Missouri Pacific):—I move to amend it by asking the Committee to also prepare specifications for a 100,000-gallon tank.

Mr. T. H. Gatlin (Southern Railway):—Will Mr. Byers concede that the Committee should also furnish specifications on 60,000-gallon tanks?

Mr. Shurtleff:—I think my motion would cover the 100,000-gallon tanks as well as the 60,000, if the Committee eliminates the dimensions, leaving them blank, but cover the specific points for wood tubs of any capacity.

Mr. Loweth:—I should be sorry to see Mr. Byers' amendment carried, because I feel that a wooden tub of 100,000 gallons capacity, while practicable, is too large for economy, and when such large capacity is desired it would generally be preferable to use a steel tank. I see no objection, however, to the Committee framing specifications for tanks of various sizes, approximating 50,000, 60,000, 70,000, 80,000 and 100,000 gallon capacities. It would be a simple matter to make specifications and tables of dimensions covering these several sizes, and there may be some who would want to use larger than the 50,000-gallon capacity tank. The Chicago, Milwaukee & St. Paul Railway has, of late, used a large number of 18 by 26 foot tanks, which have a capacity of about 70,000 gallons. With the large locomotive tenders now in use 50,000-gallon tanks are pretty small.

(Mr. Byers' motion was lost; the motion of Mr. Shurtleff was carried.)

Mr. Lindsay:—I think after tub unit capacity would be a good place to put in, "the tub capacity for 24 hours should be of such capacity as to be pumped by the day or night shift." We find we can

effect considerable economy by increasing our tub capacity, so that one pumper can pump enough to last through the night.

Mr. Ferriday:—We say that the tub unit capacity at terminals depends on the relation of consumption, cost of installation and operation, and it seems to me that covers that feature if, from the operating cost, it is more economical to make the tub unit capacity large enough to avoid pumping at night, then the capacity should be large enough for that purpose. It varies at different terminals. It seems to me that the general statement contained in the first sentence covers items of that kind.

Mr. Osgood:—I notice under the head "Tub Unit Capacity" the following occurs: "It is recommended that the unit be at least 50 per cent. greater than the maximum daily consumption when erected." In the case of a consumption of 500,000 gallons a day or more, that is a little severe.

Mr. Ferriday:—I think that for intermediate water stations, to which that section applies, that such consumption would not very often occur. The idea of the Committee is that a large consumption of that kind would probably be only at a terminal station.

Mr. Osgood:—I have in mind a case where about 700,000 gallons daily are taken. I think the phraseology might be more elastic, so as not to seem to require for good practice so large an excess over the daily consumption.

Mr. Loweth:—In line with what Mr. Osgood has said, I suggest that the last sentence of the first paragraph be made to read as follows: "It is recommended that the probable future requirements be considered." This will serve as a caution against putting in a station without making provision for the future, and avoids being so definite about a detail which, at the best, must be very uncertain and variable.

Mr. Lindsay:—We have a track tank which furnishes in the neighborhood of 900,000 gallons of water per 24 hours average. It is supplied by a 50,000-gallon tank and a duplicate system of pumps, so that if we followed that rule in such cases we would have a pretty large storage capacity.

Mr. Ferriday:—Mr. Loweth's suggestion will be accepted. We had in mind an intermediate water station consuming from 50,000 to 100,000 gallons a day. We withdraw the second sentence entirely in paragraph 2, relating to tub unit capacity at terminals. The sentence begins, "The unit capacity in this case," etc.

The Secretary:—"Water Columns.—When the cost is not of first importance, or when the objections to tank spouts are not nullified by local conditions in special cases, the use of water columns is recommended as good practice.

"Supply line should be same size as column where distance to storage tank is not over 100 ft.; where distance is greater, one size larger is recommended.

"Column pit should be waterproof and drained.

"Column valve should operate from locomotive tender only, and should be water-cushioned and provided with automatic drain for part of column above freezing line in cold climates.

"Turning device should operate from tender or ground and have automatic lock to keep horizontal part of column parallel to track.

"Horizontal pipe, when flexible joints are used, should have vertical movement sufficient to accommodate high and low engine tenders.

"All moving parts of column for operating same should be easy of access."

Mr. Osgood:—At the head of page 219 it is stated, "Supply line should be same size as column where distance to storage tank is not over 100 ft.; where distance is greater, one size larger is recommended." We have found it good practice in our case to do away with 12-in. spouts and substitute 10-in., using a 12-in. supply line, and it occurs to me some others may have had similar experience. The 12-in. spout is very heavy to handle and the delivery is practically the same with the 10-in. spout, provided the supply line is kept at 12 in.

Mr. Ransom:—Do you do that where the distance is 100 ft.?

Mr. Osgood:—We always put a 12-in. line from the tub to the standpipe, and now use a 10-in. standpipe.

Mr. M. L. Byers:—In connection with "tub unit capacity," I would like to suggest to the Committee the value of a table which would show the comparative cost of securing tub unit capacity by size of tub as compared with number of tubs. I think to any of us who have not figured that out, it would be surprising to see the slight increase in the cost of the 100,000 capacity tank over the smaller tank.

The President:—The Committee will take cognizance of that suggestion.

The Secretary:—"Operation.—Regular employés should be kept in the service whose principal business is the operation of the pumping plant. A traveling repairman should visit each plant periodically and attend to all repairs, which cannot be made when plant is running.

"Accurate records should be at hand in the office of the official having charge of this branch of the service, as indicated by Appendix E.

"Accurate reports of pumping service should be kept, as indicated in Appendices C and D."

Mr. Lindsay:—It is stated that "a traveling repairman should visit each plant periodically, and attend to all repairs which cannot be made when plant is running." Does that mean repairs which cannot be made by pumper or man in charge?

Mr. Ransom:—Yes, sir.

Mr. Osgood:—Has the question of duplicate machinery been considered?

Mr. Ransom:—A recommendation is in the body of the report, but it does not appear in the conclusions. We recommend, where a pump has to run twenty hours in order to supply the quantity of water desired, that duplicate machinery be added. I think that should be added to the conclusions.

Mr. Loweth:—I would like to inquire what is to be gained by this Association committing itself to the first sentence of the first paragraph, under the subtitle, "Operation," requiring a regular pumper for each pumping plant who should have no other duties. On the Chicago, Milwaukee & St. Paul Railway we have many water stations which are taken care of by men whose principal business is something else than pumping. We have a great many gasoline pumping plants which are taken care of by the station forces. Many of these run for long hours, and yet the amount of care and attention given them by the station forces is relatively small as compared with the other duties of these attendants. In many cases men take care of pumping stations and at the same time handle coal and ashes; the attention required for pumping is, perhaps, the least of their duties. In terminals the pumping plant may be located at a shop or roundhouse, and in such cases, although the pumping plant may be in operation most of the time, it will require but a comparatively small portion of the time of the operator, whose principal duties may be other than that of pumper. It is true that where a man has two or more duties which may at times conflict, that they are not at all times given the best attention, but the large saving resulting from these combined duties more than offsets the disadvantages. At least that has been the experience of the road I represent. It seems to me the Association will certainly gain nothing by adopting the first sentence of the paragraph referred to, but will quite possibly commit itself in a way that may be more or less embarrassing to some of the roads later on.

Mr. Ransom:—Has Mr. Loweth kept a correct record of the repairs on the line?

Mr. Loweth:—Yes, sir; we have.

Mr. Ransom:—We found from what information we could obtain on that subject from the members that the repairs would run up pretty heavily where the men had other duties to perform.

Mr. M. L. Byers:—I agree with Mr. Loweth, but would add the second sentence also. I think it is desirable to have the pumpers who are regular men make all the repairs they possibly can, and, further, there are many repairs that cannot be made by traveling repairmen. We must send the boiler to the shop to have it repaired. So I do not believe it is possible to carry out the second sentence literally. I would prefer to see both sentences stricken out, and will make a motion to that effect.

Mr. Ferriday:—The idea of the first part of the conclusion is this: In a great many cases the men who want to sell the gasoline pumping engines tell about how little the labor cost will be, and the

pump is purchased and put into operation and it runs for a while and then it commences to go all to pieces. I know from the operation of gasoline engines in running dynamos at electric interlockings that the attendance of a man is necessary. Because, if anything goes wrong, the engine runs away with itself and it makes it expensive to repair, and it also interferes with the supply, which it is very important be continuous.

The idea of putting in the second sentence was that repairmen should visit the plants periodically, not that they should make all repairs, but that periodical visits should be made by expert repairmen, and in that way the maintenance of the plant will be kept to a high standard.

Mr. Lindsay:—Speaking in support of the Committee's recommendation, there has been a great deal of left-handed economy in the operation of pumping stations, not only gasoline-driven, but steam-driven. I think it is a mistake to put a steam plant in the hands of a baggageman or station attendant, who is not qualified to operate it. I think the recommendations are proper, and this Association should go on record as being opposed to having a pumping plant in charge of a man who is not competent to run it and whose other duties are such that he cannot give the pumping plant necessary attention in preference to all else.

Mr. Ferriday:—The idea was that the pumper should be put on this work and his spare time put on other work.

Mr. Loweth:—It doubtless does cost more for the maintenance of a pumping plant which is in the care of an incompetent man or one who has other duties which may at times result in his neglecting the pumping plant. Frequently, by combining the work, we are able to get more intelligent and higher grade employés, and all of the work is thus given better attention. On the St. Paul Road many gasoline pumping plants are taken care of by station agents or helpers, for which they are paid from $7.50 to $10 extra a month. This makes the cost of labor for pumping amount to $90 to $120 a year. If regular pumpers were employed, the cost would be six to eight or more times this amount.

It is true that the pumping plants are occasionally more expensive to maintain on account of the inefficiency of these men. Even taking this into consideration, there is an advantage of large net economy.

Mr. L. R. Clausen (Chicago, Milwaukee & St. Paul):—I object to that paragraph for the reason that it lays down principles for operation for all conditions. It does not make any distinction for conditions that may exist on a railroad. The principle may be perfectly proper for a road with congested traffic, where the pumping stations furnish a large amount of water, but does not apply on a road where traffic is light and the stations are not required to furnish a great amount of water. I do not think it good policy for the Association to advance or define a particular principle to cover

all conditions. If you wish to define a policy, make some distinction in the conditions. If we followed the policy outlined here, it would make an addition to our operating expenses which is not justified, because we are furnishing water satisfactorily by using employés whose principal duties are other than that of pumping.

(The President then put the combined motions of Messrs. Loweth and Byers, and the first section under "Operation" was stricken out.)

Mr. W. F. Steffens:—The word "same" is used twice on page 216 in referring back to something different each time. I call that to the attention of the editing committee.

Mr. M. J. Henoch (Louisville & Nashville):—I want to ask whether the subject of reinforced concrete tanks has been considered? If not, I move that the Committee be requested to investigate and report on the subject.

Mr. Ransom:—The subject has not been considered, because we have not been able to find any that have been built.

Mr. Henoch:—I have not any particular information on the subject, but I have noticed reports at different times in engineering periodicals of reinforced concrete tanks that have been built at various points, and I think it would be valuable to at least collect some information on the subject.

Mr. Ransom:—I move the adoption of the Committee's report as amended.

(Motion carried.)

Mr. Edwin F. Wendt (Pittsburg & Lake Erie):—Will the chairman indicate just what is to be included in the Manual?

Mr. Ransom:—The idea of the Committee is to have what is printed in boldface type, and in addition to that the diagrams printed in the body of the report.

The President:—The Committee will be excused with the thanks of the Association.

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